Customer-Led Network Revolution

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Acronyms

ADMD – After Diversity Maximum Demand

BSC – Balancing and Settlement Code

BSUOS – Balancing services use of system charges

CAF – Cost Apportionment Factor

CCCM – Common Connection Charging Methodology

CDCM – Common Distribution Charging Methodology

CLNR – Customer Led Network Revolution

DCC – Data Communications Company

DCPR5 – Distribution Price Control Review 5

DCUSA – Distribution Connection and Use of System Agreement

DECC – Department of Energy and Climate Change

DG – Distributed Generation

DNO – Distributor Network Operator

DSM – Demand Side Management

DSO – Distribution System Operator

DSR – Demand Side Response

DUoS – Distribution Use of System

DSBR – Demand Side Balancing Reserve

EBSCR – Electricity Balancing Significant Code Review

ED1 – Electricity Distribution 1

ED2 – Electricity Distribution 2

EDCM – EHV distribution charging methodology

EE – Energy Efficiency

ENA – Energy Networks Association

EES – Electrical Energy Storage

EHV – Extra High Voltage

EMR – Electricity Market Reform

ENA – Energy Networks Association

ETR – Engineering Technical Recommendation

EV – Electric Vehicle

FR – Fast Reserve

FFR – Firm Frequency Response

GUS – Grand Unified Scheme

GB – Great Britain

HH – Half Hourly

HP – Heat Pumps

HV network – High Voltage network

EHV network – Extra High Voltage network

I&C – Industrial and Commercial

IHD – In-Home Display

IIS – Interruption Incentive Scheme

IQI – Information Quality Incentive

LCNF – Low Carbon Network Fund

LCT – Low Carbon Technologies

LV network – Low Voltage network

mCHP – Micro Combined Heat and Power

MIP – Market Index Price

NETSO – Network Electricity Transmission System Operator

NO – Network Operator

OCGT – Open Cycle Gas Turbine

PC – Profile Class

PV – Photovoltaics

RIIO – Revenue = Incentives + Innovation + Outputs

SBP – System Buy Price

SBR – Supplemental Balancing Reserve

SEC – Smarter Energy Code

SME – Small and Medium-sized Enterprises

SGF – Smart Grid Forum

SGF WS6 – Smart Grid Forum Work Stream 6

SO – System Operator

SSC – Standards Settlement Configuration

SSP – System Sell Price

STOR – Short Term Operating Reserve

SToU – Static Time of Use

ToU – Time of Use

TSO – Transmission System Operator

WS – Work Stream

1 Executive summary

The Customer Led Network Revolution (CLNR) project is a customer-oriented innovation project. Customers in the residential, small and medium enterprise (SME), industrial and commercial (I&C) sectors have been engaged to trial new ways of managing networks, with the objective of facilitating the accelerating uptake of low carbon technologies and providing customers more choice in how they use and generate electricity.

The increasing adoption of low carbon technologies and distributed generation is expected to result in increased loads on distribution networks and changing patterns of demand, potentially giving rise to new issues such as reverse power flows. CLNR has trialled a range of Demand Side Response (DSR) interventions that can potentially allow more loads to be connected to a circuit by reducing peak network demand and increasing network utilisation, thereby deferring the need for network reinforcement investment. The flexibility in customer demand accessed through these demand side response interventions can also provide useful services to other stakeholders, including suppliers, generators and transmission system operators. The requirements of these other stakeholders may at times be complementary but at other times may conflict with the requirements of distribution network operators. This provides an opportunity for new business models between these stakeholders and potentially creates a requirement for new regulations to ensure that DSR resources are most effectively deployed and ultimately that maximum benefit is delivered to the customer.

This report considers the use cases for DSR and the value of the response to each stakeholder. In particular it focuses on the demand side response interventions that have been trialled in the CLNR project and assesses the implications of the insights gained through these trials for the adoption of the interventions as part of business as usual and the potential commercial arrangements needed to support them.

The key insights related to each of the customer segments that have been involved in the CLNR trials – residential, SME and industrial and commercial (I&C) – are summarised in the following.

Key conclusions on interventions trialled in CLNR

Residential DSR – Static time of use tariffs have been successfully demonstrated in CLNR via a supplier hub model. There are no major barriers to implementation, although pre-requisites exist for roll-out as BaU (smart metering, three-rate DUoS tariffs and modified settlement codes). Clear incentives for suppliers to offer tariffs and for customers to take them up are needed. Residential ToU tariffs are expected to become more prevalent toward the end of ED1 and into ED2

I&C DSR – Available for EHV / HV post-fault management from ED1 onwards. There are no major barriers to a bilateral contracting approach or to contracting via aggregators. A more integrated sharing framework, enabling DSR providers to offer services to multiple stakeholders, could provide improved access to the market.

SME DSR – Similar preconditions for uptake of static time of use tariffs as in the residential sector exist. There are significant barriers in the engagement of SME providers, due to concerns regarding negative impacts on business, heterogeneity of the sector (limits standardised offers) and lack of coincidence of SME loads with the system peak period. Some suitable loads have been identified and some success in engaging SME providers has been demonstrated. This sector seems less likely to be a near term source of DSR in significant volumes.

Electrical Energy Storage (EES) – Provides useful voltage support and load management services to DNOs. A range of commercial models exist involving varying degrees of DNO and third-party operation and ownership and offering varying degrees of DNO control and risk. The key barrier to deployment of EES is the cost, which is high compared to alternative reinforcement options.

Residential

CLNR has successfully trialled a residential static Time of Use (SToU), tariff which reflected the value of shifting demand for peak reduction for network operators and wholesale cost reduction for suppliers.

The successful implementation of residential SToU tariffs via a supplier-hub arrangement is a major success of the CLNR project. The supplier was able to pass on the ToU incentives through the electricity bill and settled these customers using adapted profile class 1 Standard Settlement Configurations (SSC). The project did encounter some inefficiencies with this settlement process, however it is likely these could be addressed with increased experience of the process. This route for settlement is available to suppliers in the short-term, with development of three rate Distribution Use of System

(DUoS) charging for profile classes (PC) 1-4, through DCUSA change DCP179 – 'Amending the Common Distribution Charging Methodology (CDCM) tariff Structure' and Balancing and Settlement Code (BSC) proposal P300 – 'Introduction of new Measurement Classes to support Half Hourly DCUSA Tariff Changes (DCP179)', with an implementation date in November 2015. Half hourly settlement of residential customers could allow the benefit of these interventions to be captured more fully.

Customers showed a 3.2%-12.5% lower average peak power demand during peak periods compared to a control group. However, the peak demand during the day of largest network stress was not lower. This is a critical issue for Distribution Network Operators (DNOs), as the annual peak loads are key drivers of network reinforcement.

The CLNR trials with direct controlled washing machines and heat pumps showed that these can have a statistically significant contribution to demand reduction when instructed. This has been successfully demonstrated on the CLNR project despite the inevitable technical issues associated with the first UK application of these technologies.

This indicates that some form of load control or appliance automation in combination with a SToU tariff could provide a higher reliability of response at moments of need for the DNO. Alternatively additional communications or incentives (e.g. critical peak pricing) may be able to increase response reliability at moments of need, this has however not been trialled in CLNR.

The CLNR trials showed that having an override function on direct load controlled appliances did not materially impact the reliability of response, i.e. it wasn't used often. This is encouraging, as the lack of control over one's own appliances is often seen as a barrier for customers to adopt direct load control interventions. These results show that when an override is provided this doesn't necessarily impact the value for the DNO significantly, and could give reassurance of control to customers.

The trials showed that while 60% of the trial participants on the SToU trial saved on their bills over the course of a year, for approximately 40% of the customers their electricity bill was higher than it would have been under the standard flat tariff, though this difference was refunded as part of the trial. It was possible to compare two demographic indicators between ToU tariff customers and the control group: housing tenure (renter/home owner) and the existence of dependents in the household. It was found that home owners and households without dependents were more likely to display a different energy use pattern under a ToU tariff compared to the control sample. This potentially limits the impact of voluntary ToU tariffs, as those that are worse off would be likely to stay or switch-back to a flat tariff.

Small and Medium Enterprise (SME)

The CLNR trials showed that engagement of SMEs in DSR propositions and response to DSR signals can be successful. However, the CLNR experience has indicated that the SME sector represents the most difficult group to engage in DSR.

Key challenges in engaging SMEs are driven by the risks perceived by SMEs around the impact of load reduction on the daily running of the business. The ability to override any direct control type intervention may support uptake.

Other barriers are the heterogeneity of the sector and sometimes limited overlap of flexible demand with network peak demand. To address these, CLNR has provided a deeper understanding of subsector consumption profiles and identified specific appliances that could provide useful flexibility. The CLNR trials indicate that parties wishing to procure DSR from SMEs may find it most effective to offer a “menu” of DSR contracts to reflect features of the diversity of loads available from SME customers.

Industrial and Commercial (I&C)

CLNR has successfully trialled provision of on demand DSR with industrial and commercial customers on a commercial basis.

The successful DSR trials with I&C customers have demonstrated the following:

- DSR service procurement by a DNO from I&C customers on commercial contracts is possible, both through aggregators and directly with customers. The project has developed three separate commercial contracts to procure such DSR services.
- I&C customer willingness to adopt different contract and payment structures for the provision of post-fault network management through generation support, demand reduction and demand shifting.
- Signalling for DSR using an active network management system, both through aggregators and directly with customers.
- Load reduction at the primary substation at moments of simulated stress, resulting from the provision of DSR.

The lack of arrangements for sharing of these DSR resources between stakeholders is a key barrier to DNOs use cases. This has implications for the revenue that customers can capture from different stakeholders and also impacts the DSR supply. This is key, as the price signal that the DNO alone is able to provide may not be sufficient to incentivise customers. The potential value of deferring investment costs by providing DSR in post fault situations is of the order of £17/kW/yr, based on a typical reinforcement case, compared to approximately £30/kW/yr for the provision of Short Term Operating Reserve (STOR). The price signal the DNO could send per MWh for post fault management, could in some cases however be very high, as the response may sometimes be needed for only a few hours per year.

Another key aspect for the deployment of these interventions as business as usual, is the expected reliability of these resources. CLNR has provided further insight in to the reliability of I&C DSR, which can inform F factors. The F factor represents the extent to which a resource contributes to firm capacity. The DSR resources that participated in the I&C trial had an average reliability of availability of 50% and a success rate when called of 94%. This implies that a portfolio of resources is required to guarantee a firm response when called.

The CLNR trials furthermore showed the challenge in engaging sufficient suited DSR resources in a specific stressed area of the network to defer network reinforcements. In the trial, DSR providers were required to individually meet the DNO use case requirements in terms of availability and utilisation for post-fault management at primary substation level. This reduced the number of customers able to participate in these schemes. A solution to this issue is to use a portfolio of customers to deliver the DNO's requirements, each contributing towards the total requirement.

Electrical Energy Storage

As part of the CLNR project, six Electrical Energy Storage (EES) assets of varying capacities were installed and operated by Northern Powergrid including the deployment and operation of one of the largest grid connected batteries in the UK (5MWh). For the first time the batteries and networks were also monitored through an Active Network Management system.

The electricity storage trials in CLNR have focussed on the network management and technical aspects of storage rather than the commercial arrangements. The batteries have been sited on Northern Powergrid's network to understand how the technology works across different network areas. The locations are chosen such that combined they offer a representative sample of 80% of the UK's total electricity distribution network.

Next steps

From the start of RIIO-ED1 I&C DSR could be deployed commercially, while the underlying drivers for residential DSR are further developed.

CLNR showed that the provision of DSR for post network fault management from I&C customers can be deployed commercially in the near term (RIIO-ED1), and does not require significant changes to industry codes. Auctions are identified to be the most suited procurement route, because of the very case specific alternative cost of conventional reinforcements and uncertainty on the price level required by DSR providers. Enabling DSR providers to offer services to multiple stakeholders efficiently, including network management purposes, can support the unlocking of additional DSR resources. A coordinated industry approach to jointly accessing DSR resources can support this in the near term. Such a rules based framework is for instance being developed in the Energy Networks Association (ENA) shared services framework.

The CLNR trials have found that voluntary adoption of static DSR through suppliers is a feasible route to engage residential customers. DNOs are however unlikely to proactively deploy such propositions in a geographic area, because of the need to engage with a large number of customers. Uptake is therefore more likely to be supplier led, requiring a clear incentive to offer these tariffs, which is currently limited.

Other preconditions for the deployment of residential ToU tariffs include smart meter roll out, uptake of three rate DUoS charging and more effective settlement on adapted SSCs.

Although there are few direct barriers for residential ToU tariffs, the drivers for uptake by individual customers are not very strong and a number of preconditions need to be deployed over the coming years. Residential ToU tariffs are therefore expected to be taken up at scale commercially towards the end of RIIO-ED1 and in RIIO-ED2. In the period leading up to that the key underlying drivers can be further developed, and new business propositions developed.

2 Introduction

2.1 Customer-Led Network Revolution project

This report has been commissioned by the Customer-Led Network Revolution (CLNR) project, which is supported by Ofgem's Low Carbon Network Fund. The main premise of the CLNR project is that the reinforcement of electricity distribution networks required to cope with large-scale take-up of low carbon technology can be delivered most cost-effectively and efficiently by using a combination of new network technologies and flexible customer response from both demand and generation. While many of the technical solutions exist, they have not been deployed at scale at the distribution level in an electricity market with the degree of vertical separation as that operating in Great Britain (GB).

CLNR is a customer-oriented project. Customers in the residential, commercial and industrial sectors have been engaged to trial new ways of managing networks, with the objective of facilitating the accelerating uptake of low carbon technologies and providing customers more choice in how they use and generate electricity.

2.2 Objective and scope of this report

This report is the continuation of the first commercial arrangements report, written by Element Energy and published by CLNR in 2013, which provides a detailed assessment of the legislative framework and commercial arrangements currently operating in the GB electricity market.

2.2.1 Objective

This report builds on the results and learnings from the CLNR trials to understand the role of the various customer-led interventions and their value in the electricity system, especially for DNOs. It reviews the key use cases for these interventions and their requirements, compares the relative value of these for different stakeholders and considers the opportunity to combine different value streams. An overview is provided of the key barriers that existing arrangements pose to the deployment of DSR solutions. Based on this review potential new commercial arrangements are assessed to bring the trialled interventions to business as usual.

2.2.2 Scope

The scope of this report covers the CLNR customer interventions, and the electricity storage trials. These are reviewed in a wider framework of industry demand side management options. The CLNR project also explored a range of other network solutions, which are not assessed in this report. The focus of the report is on the RIIO-ED1 price period (2015-2023), with an outlook to the next price period. The report is based on the CLNR learnings and trial results, interviews and workshops with the CLNR project, and a review of UK and international literature. Previous and ongoing work in the UK, including Smart Grid Forum Work Stream 6 (SGF WS6) and other Low Carbon Network Fund (LCNF) projects have also been reviewed and their results cross-referenced with the CLNR trials findings.

Specifically, this report covers:

- The different types of DSR.
- The drivers and use cases for DSR.
- The application and take-up of DSR in different customer sectors.
- The value of DSR to players in the electricity supply value chain (i.e. Generators, Suppliers, Transmission System Operators, Transmission Network Operators and Distribution Network Operators).
- The commercial and regulatory barriers to DSR and their potential solutions.
- Potential future commercial frameworks and the timescales for their evolution.

2.2.3 Organisation of the report

The report is arranged into three sections, as follows:

Section 1: Demand side response characteristics and use cases – this section provides introductory material on the various types of DSR, its key characteristics and the way in which DSR can be used by different stakeholders.

Section 2: CLNR interventions and the DSR value chain – this section reviews the findings of the CLNR trials in detail and the insights gained into how these interventions could be rolled out as business as usual. This section also considers how the value of DSR interventions is distributed among stakeholders in the market.

Section 3: Barriers and new commercial arrangements – This section reviews the barriers to adoption of DSR in the current market arrangements and identifies the next steps required to facilitate adoption of DSR in the short to medium term. The section also explores possible longer-term commercial models that may facilitate more efficient deployment of growing volumes of DSR in the future.

SECTION 1 – Demand Side Response Characteristics and Use Cases

3 Demand Side Response Characterisation

3.1 Definition of Demand Side Response

Figure 1 Elements of demand side management

During CLNR a range of customer-led Demand Side Response interventions have been trialled. DSR is part of the broader concept of Demand Side Management (DSM), which also includes Energy Efficiency (EE)[1] and Electricity Energy Storage (EES).

- **Demand Side Response (DSR)** is a change in electricity demand pattern by a customer in response to a signal from another party, and is hence a customer led approach. It can be used alongside energy efficiency or electricity energy storage to reduce peak demand or to provide specific services. DSR can be provided either by pure load response, or by backup generation and embedded generation.

- **Energy Efficiency (EE)** is the reduction of overall energy demand, and hence, peak demand, through measures such as more efficient appliances or processes, low energy lighting and improvement of the building's thermal efficiency.

- **Electricity Energy Storage (EES)** is where electricity can be stored using a range of technologies, including batteries, pumped hydro, flywheels, compressed air and various other technologies. EES can be seen as a distinct asset class, which can provide functionality similar to both demand and generation.

3.2 Drivers for DSR

The transition to a low carbon economy presents both challenges and opportunities for the electricity industry and customers. The electrification of transport and heating has the potential to increase electricity demand and change consumption patterns. The

[1] There is not a unified classification of the different concepts related to demand measures – e.g. the Cambridge Electricity Policy Research Group define DSM as a combination of DSR and EE while the EURELECTRIC group defines DSP as a combination of DSR and DSM (Available at: http://www.econ.cam.ac.uk/dae/repec/cam/pdf/cwpe1060.pdf and http://www.eurelectric.org/media/61240/dsp_report_0810-02_simple_page_final-2011-030-0638-01-e.pdf)

increasing deployment of distributed generation (solar Photovoltaics (solar PV) and micro Combined Heat and Power (mCHP) could cause reverse power flows, leading to local voltage rise and peak loading issues, due to the increased intermittency and unpredictability of electricity generation. GB peak electricity demand could increase by 25% from ~60GW today to ~75GW in 2030, with a contribution of 20GW from Heat Pumps (HPs) and 5GW from Electric Vehicles (EVs) in the Smart Grid Forum (SGF) Work Stream 3 (WS3) scenario1[2]. WS3 reviewed a range of scenarios for the uptake of Low carbon Technologies (LCTs), with HP uptake varying from one to eight million residential installations in 2030, and EV uptake from four million to eleven million vehicles in 2030.

DSR interventions may provide cost-effective alternatives to network reinforcement to mitigate the impact of these changing requirements on UK's distribution networks, while reducing consumers' electricity bills and enabling novel energy propositions for customers. The deployment of DSR solutions is also being enabled by the development of information and communication technologies and the roll out of smart meters. Larger non-domestic customers already have advanced metering[3]. The Government's ambition is for all households and other small energy customers to have smart meters installed by their energy suppliers by 2019 and have the opportunity to engage in demand side response.

3.3 DSR categories for commercial arrangements

We distinguish between four key characteristics of DSR that impact the commercial arrangements for its deployment:

Frequency of Utilisation: the interventions vary significantly in how often response is required / provided. This ranges from day-in-day-out responses such as from domestic static Time of Use (SToU) tariffs to infrequent calls for on-demand DSR for post network fault management.

Incentive: is a key aspect in how customers are incentivised to provide DSR. In CLNR two main methods have been trialled. In some interventions customers were incentivised through their electricity bills (either through ToU tariffs or through reduction of electricity imports). In other interventions (mainly for I&C customers), direct payments were provided through bilateral contracts.

Visibility and Availability: with ToU tariffs the DNO has no direct visibility of individual responses and relies on the statistical aggregate behaviour of many customers. In interventions where I&C customers are contracted to provide DSR as a service, a specific, on-demand, response is requested from individual customers and is verified by the DNO or by an aggregator on behalf of the DNO. In both cases the reliability and validation of responses is a key aspect to assess the contribution of DSR for network design.

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2 SGF WS3 Scenario 1, DECC high projection for HPs and moderate projection for EVs and PVs

3 HH meters are mandatory for all business users with a maximum demand of 100 kW or more. Businesses with lower demand (but more than 70kW) have the option to have a HH meter.

Dynamics: the requirement for DSR can be static (i.e. unchanging over the year) or it can be dynamic to provide a signal at specific moments that a response is required.

Based on these characteristics we define three distinct DSR categories that frame the CLNR interventions: Static Response, Dynamic Response and On-Demand Response.

Table 1 DSR categorisation for CLNR interventions

DSR category	Static response	Dynamic response	On demand DSR
Frequency	day-in-day-out	day-in-day-out	on demand
Payment	electricity bill	electricity bill	direct payments
Visibility	statistical aggregate	statistical aggregate	Specific response contracted
Dynamics	Static	Dynamic	Dynamic
CLNR trial examples	SToU restricted hours	in premise balancing	I&C contracted Direct load control

The suitability of DSR resources for different use cases also depends on the DSR technical characteristics. These are not in the scope of this report, but a high level assessment is included in section 4.5, to map DSR resources against potential use cases.

3.4 DSR provision in different customer sectors

The scale, pattern and flexibility of electricity usage and the barriers for the uptake of DSR vary strongly between sectors. The CLNR project has trialled DSR in three customer sectors:

1. Industrial and Commercial customers (I&C) – Half hourly metered I&C enterprises
2. Small and Medium Enterprise customers (SME) – Non half hourly metered businesses or commercial enterprises
3. Residential customers – Elexon profile classes (PC) 1 and 2

The flexibility potential of I&C customers strongly depends on their specific process requirements, as well as on their operational demands. Residential customers are more homogeneous in the type of appliances, and the extent of flexibility depends more on practices and behaviour. SMEs show characteristics of both, with a number of generic usages, and varying business types and operational demands. The trial recruitment indicates that engagement of SMEs may be the most difficult of the three sectors [20].

In both residential and I&C sectors some forms of DSM are already well-established. Some 17% of UK households for instance have domestic restricted tariffs (Economy7 or Economy10), with night storage heaters or other thermal storage[4]. In I&C sectors the provision of ancillary services and TRIAD management are established forms of DSR although these are often provided by backup and embedded generation. For instance in 2012, around 45% of the STOR capacity was provided from demand side[5].

[4] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/337649/chapter_5.pdf

[5] 'Overview of National Grid's Balancing Services', National Grid presentation during Ofgem day, 20 November 2012

4 Use Cases

This section provides an overview of key DSR use cases for stakeholders in the electricity value chain. Each use case has specific commercial, operational and technical requirements. The focus of the assessment is on DNOs, however, use cases for other stakeholders (transmission system operator, supplier and generators) are also summarised and reviewed. These key use cases have been selected based on a comprehensive literature review, interviews with commercial, regulatory and technical experts from the DNOs and suppliers and workshops with partners from the CLNR project. This section also provides an illustrative overview of the potential revenue of different use cases, as summarised in Figure 2. These values are based on the typical cost of current incumbent solutions for those use cases[6] and are derived from an extensive literature review[7]. The aim is to both provide a comparison of the relative value of different DSR use cases and to provide insight into the scale of the potential value for customers. All values are therefore expressed in terms of a common metric – £/kW/yr. The future cost development of these incumbent solutions could vary significantly for different use cases. The DNO conventional reinforcement costs for instance could be expected to be more stable than the development of wholesale market prices and volatility which underpin the wholesale cost reduction potential for suppliers.

A key characteristic for the use of DSR by DNOs is the need for response in specific locations on the network. Suppliers or system operators, on the other hand, mostly use DSR on a system level which can be provided from any location.

A key distinction between use cases is whether they depend on specific local conditions or on national system conditions. The ability for instance to use DSR to reduce local network peak loads depends on local network conditions and availability of sufficiently controllable demand in the right location.

A second characteristic for DSR use by the DNO, especially to address network stress[8] at High Voltage (HV) level and for post-fault management, is the infrequent need for a response. This may be called for only a few hours per day and year, but when called, could be needed for several weeks.

[6] The cost of DSR solutions and potential to share revenues are addressed in the next section and are not taken up in this overview of potential revenues.

[7] [1][2][3][4][5][6][12][15][18][27][28][39][40]

[8] Due to demand, local generation or fault conditions

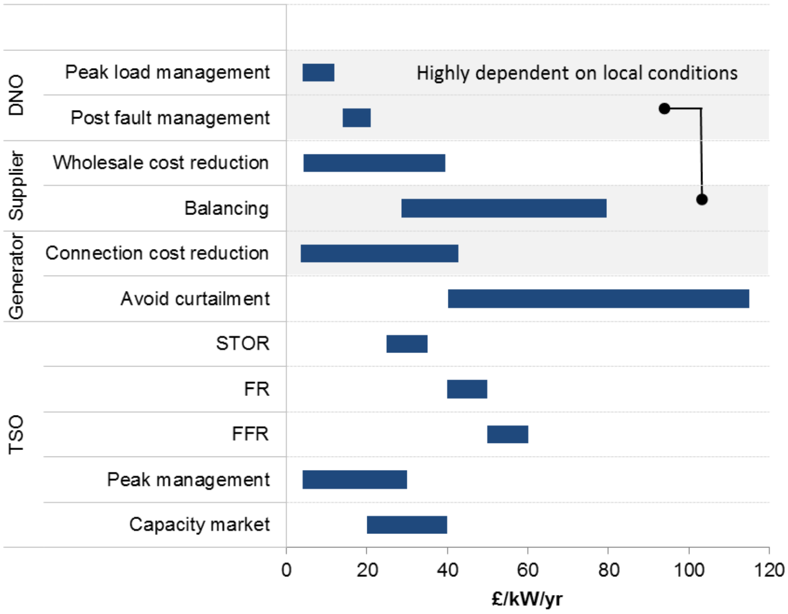

Figure 2 Illustrative potential avoided cost for DSR use cases, based on typical cost of current incumbent solutions[9]

4.1 Distribution Network Operator

4.1.1 Peak load management

DSR can potentially allow more load to be connected to a circuit by reducing peak demand, either continuously or just post fault, and thereby defer the need for network reinforcement investment.

Key drivers for these use cases are the anticipated increase in electric transport and electric heating. Different studies have assessed the potential impact of clustered uptake of low carbon technologies, demonstrating that clustering could create local network issues even at relatively low levels of uptake overall ([32], [33], [36]). Clustering effects at the start of electric vehicle roll-out have for instance been reported to be likely due to social demographic factors [35], and heat pumps may initially be clustered in new developments [38] .

Some forms of peak load reduction are already embedded in the common distribution charging methodology (CDCM) and the EHV distribution charging methodology (EDCM) through unit rate charges for consumption at the time of DNO peak (super-red time

[9] For static Time of Use tariffs the diversity of customer responses reduces their contribution to the aggregate network peak load reduction. The peak load management use case includes a 0.2 coincidence factor (typical for about 100 customers [18]. TSO peak management lower range is similar based on residential customer contribution after diversity, while high range is based on EHV connected customers without diversity. Post fault management based on a 5 year deferral of reinforcement costs.

tariffs). These methodologies are reviewed more extensively in the first CLNR report on commercial arrangements [7].

Post fault demand-side response (EHV and HV systems)

In order to maintain security of supply standards, EHV networks are designed to have full redundancy, so that in the event of single fault there will be no loss of supply. HV networks are designed to have spare capacity so that supplies can be rerouted in the event of a single fault, but customers could go off supply until the switching has taken place to isolate the fault and reroute supplies.

In the case of a single fault, DSR only needs to be deployed to keep the network within thermal and voltage limits until the fault situation is resolved. This reduces the amount of redundant capacity required, thereby deferring reinforcement investments and reducing costs for customers. For the value analysis, a base case deferral of a £1.5m investment for 5 years is assumed for this use case, which is further discussed in section 5.1.3.

As DSR is only required for this use case for a network fault that occurs at the time of peak loading, demand reduction of controllable load throughout a peak period can contribute to deferral of reinforcements, and there is less need for day-in-day out peak reduction.

In the event that a network fault leads to insufficient network capacity, or a double fault situation, the value of DSR could potentially be very high. Post fault disconnection of controllable loads during a peak period, or where restoration spans across a peak period, can enable other loads to stay connected or become restored sooner. Without DSR the customers on the part of the network with reduced capacity due to a fault would have to be disconnected. The use of DSR for this purpose would avoid the payments the DNO would otherwise need to make under the Interruption Incentive Scheme (IIS). The IIS incentives are set by Ofgem, based on the Value of Lost Load. For Northern Powergrid these are of the order of £18/customer/hr in the current price control period, and are expected to increase to around £30/customer/hr in the next price control period[10]. The potential value for DSR to limit disconnections is high, but it will be called on very infrequently and is highly dependent on local conditions.

Day-in / Day-out demand-side response (LV systems)

DNOs have specific requirements for deploying DSR for peak load management on LV systems. The response is required during periods of peak local network demand, sufficient scale and reliability of response are required and it needs to be available at constrained locations on the network.

LV networks are built to capacity without additional redundancy, i.e. without multiple additional incoming supplies. In order to defer reinforcements, peak demand needs to be reduced day-in-day out during periods when demand is highest (usually the winter period).

Contribution to network peak demand reduction

A key element in determining the value of individual DSR interventions to the DNO is the extent to which these responses contribute to overall network peak demand reduction. The two key elements that influence this are the reliability of individual responses and the diversity of group responses.

DNOs require a high certainty on the magnitude of the peak reduction that will be attained. This can be provided either by a high guarantee of response or by relying on a statistical aggregate response.

The overall peak demand reduction depends for all DSR categories on the reliability of individual responses, which needs to be factored in to future planning standards for network reinforcement. Following the approach in Engineering Technical Recommendation 130 (ETR 130)[11], the contribution of different types of DSR to security of supply could be weighted using their confidence factors (F factor). For on-demand services there is a commercial need to verify the response that is provided. In the case of statistical aggregate responses, this is not required.

The diversity of responses, or the coincidence, is a further critical aspect for DSR interventions that rely on the statistical aggregate response from a group of providers (the static and dynamic response categories). For demand, a typical After Diversity Mean Demand factor for 100 and 1000 customers is 0.2 and 0.1 respectively [18]. Similarly aggregate demand response for network peak demand reduction by a group of customers is dependent on the diversity of their response. However, it could be expected that the coincidence is higher for peak demand reduction than for normal household consumption. The above factors are taken as upper bound for the coincidence on LV and EHV respectively.

A corresponding risk in deploying direct load control DSR is that it could reduce the natural diversity of demand. A group of washing machines for instance show a diversified consumption under normal circumstances. However, if a group of direct controlled washing machines are all turned back on simultaneously after a DSR event, the total demand increase could coincide strongly leading to an increase in the peak after the event. This effect was observed in the CLNR washing machine direct control trials. With large scale or clustered uptake of similar DSR propositions this could limit the network

[11] Engineering Recommendation (ER) P2/6, security of supply; and Engineering Technical Report (ETR) 130, application guide for assessing the capacity of networks containing distributed generation.

benefit for DNOs. Randomisation of event windows, similar to teleswitching, could help mitigate these effects. Other solutions may include addressing this issue in system and product standards. To offset reinforcements, sufficient DSR capacity needs to be available in specific network areas. The amount of DSR capacity that is required to offset a network reinforcement is very case specific, and also depends on projected load growth for the area,

Use case value

DNOs could deploy DSR solutions for peak load management if the total costs of DSR are lower than the counterfactual annualised conventional network reinforcement cost. The costs to the DNO include DSR payments to customers (these can potentially be reduced when DSR resources can be shared by different users) and the cost of operating DSR schemes. Whether DSR provides the most cost effective option for a specific project critically depends on:

- **Project specific counterfactual reinforcement costs.**
- **Confidence factor of DSR resources.**
- **Sufficient DSR capacity co-located to resolve network constraint.**
- **Length of time over which costs are deferred or actually mitigated.**
- **Ability to share DSR resources with other stakeholders.**

The counterfactual reinforcement costs depend critically on the location of the network constraint and the assets required to increase capacity sufficiently to remove the constraint. The demand reduction needs to be realised downstream of the constraint. DSR at the lower voltage levels can therefore also provide more value (in £/kW response) because they can be used to relieve constraints at all the higher voltage levels.

Yardstick values for reinforcement costs can provide an indication of the cost at which DSR solutions could be competitive. These will however over represent the scale of reinforcement costs for many specific cases, as these are driven by the specific assets required to increase capacity sufficiently to remove the constraint, Yardstick values for Yorkshire and the Northeast are presented in Figure 2, based on the common distribution charging methodology (CDCM) model inputs from Northern Powergrid[12].

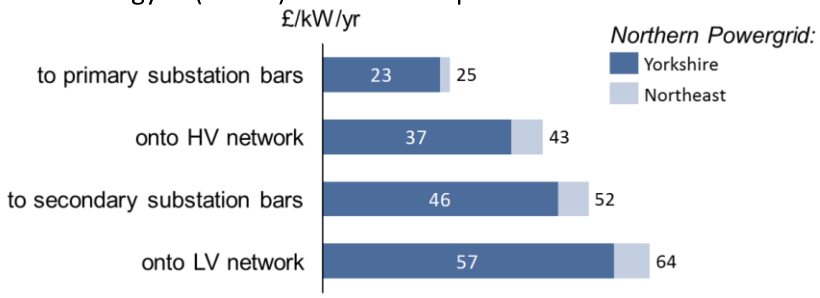

Figure 3 Northern Powergrid yardstick values for network reinforcement costs

[12] These are based on the per unit cost of 500MW incremental expansions of a network

The yardstick values for reinforcement costs presented in this report are similar to network reinforcement costs published in other studies, which range from 25 £/kW/yr to 50 £/kW/yr [4] [3]. Analysis of the value of DSR for network peak reduction by Poyry [4] [5], based on archetype grids, is also in line with the yardstick values, taking into account corresponding coincidence factors.

The value of peak demand reduction to the DNO also depends on whether reinforcement needs are avoided or deferred. With underlying projections of increasing demand, DSR may in some instances only be able to delay when reinforcement is required which will reduce the effective value of the DSR intervention. However, the use of DSR to even temporarily resolve network stress also provides an option value. For example in the intermediate time that the DSR solution is in place, demand forecasts may change and reinforcement may no longer be required, the network situation may change favouring another option that would not have been selected earlier or a different more cost effective solution may have become available.

Providers of on-demand DSR enter into bilateral contracts with DNOs or through aggregators or suppliers and receive payments from the DNO for their DSR services. The structure of possible commercial contracts is discussed further in section.5.1.3. Customers that provide DSR through ToU tariffs could receive benefits through reduction of DUoS charges in their electricity bills. If DSR solutions result in lower costs compared to the assumptions already embedded in DNO business plans, these savings can be shared with all customers through lower DUoS charges, this is further discussed in section 8.1.

4.1.2 Peak export reduction

With increasing levels of embedded and behind-the-meter distributed generation, increasing peak exports at minimum demand times could lead to voltage rise issues and thus the need for network reinforcements. DSR[13] can be used to manage peak export from embedded generation using techniques such as in-premises balancing, as has been trialled within CLNR for customers with photovoltaic cells. Whether this reduces DNO costs depends strongly on local network and embedded generation conditions.

Increasing the self-consumption of behind-the-meter generation can also provide direct savings on consumer electricity bills. On a flat tariff, this value is currently equal to the difference between the consumer's electricity price (~16p/kWh) and the reimbursement for exported electricity, typically the wholesale electricity price (~4.5p/kWh). Responding to these dynamic export peaks requires Dynamic Response or On-Demand forms of DSR or storage.

[13] In this study in-premise balancing is discussed alongside DSR, as it has similar impacts as other DSR options. With in-premise balancing there is however no signal for response from a third party, the response derives from potential savings on electricity consumption.

4.1.3 Reduced connection cost

DSR could potentially be used to reduce generation connection costs by providing a controllable increase in demand which would limit net peak generation export. For the value of this use case we consider HV connected distributed generation, governed by engineering recommendation G59/2. Connection charges apply to extensions of the network (sole use assets) and reinforcements to accommodate the generator. Sole use assets are paid for by the generator. Reinforcements are shared between the generator and the DNO, depending on whether the reinforcements are the minimum or an enhanced scheme and the Cost Apportionment Factor (CAF). The costs of connecting vary significantly, depending on local network conditions and required extension. Typical costs of network reinforcements for new generation can fall within a wide range, from £60k/MW to £750k/MW [6][27].

For this use case the responsive load needs to be sufficiently controllable and reliable to provide certainty that net generation is reduced, and the DSR resource and generator need to be co-located behind the same network constraint that would require reinforcement. Especially for distributed wind at HV level the extent to which generation and sufficiently controllable demand are co-located may be limited.

Similarly to the case of DG, DSR might be used in the future for the reduction of connection costs for large loads (i.e. electric vehicles and heat pumps).

4.2 Supplier

4.2.1 Wholesale cost reduction

Suppliers can use demand side response to shift consumption from peak price periods to lower price periods, and reduce overall wholesale purchase costs. These savings can be passed on to consumers through lower commodity costs in electricity bills. The value of DSR for this application strongly depends on the time of year and the periods between which demand is shifted.

Planning of DSR for this use case would typically be carried out prior to the day of delivery. Critically the value of DSR in this use case depends on the (kWh) demand shifted by individual customers and does not depend on the (kW) coincidence between customers.

Currently peak and off-peak prices are strongly correlated with demand and hence time of day. With increasing levels of intermittent generation, this link may become less strong and prices may become more strongly correlated with intermittent generation. As prices become less correlated to time of day and especially in scenarios with more unpredictable load, dynamic forms of DSR might be able to capture more value than static time of use tariffs, by shifting demand at observed periods of high price.

The wholesale price differentials for demand shift between peak price periods and shoulder and off-peak periods are depicted in Figure 3. These values are consistent with other studies for this use case, which typically range from 0.01£/kWh to 0.07£/kWh [3][4][5][15]. Whilst the value per unit of demand shifted is limited compared to some other use cases, the total system cost reductions could be very high if large volumes of demand are shifted, as evidenced in the same reports.

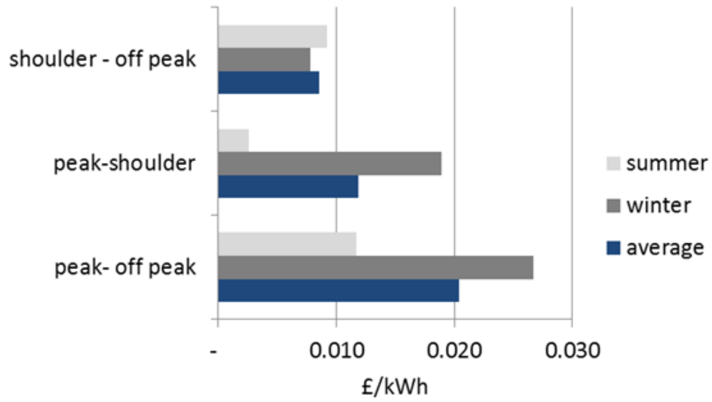

Figure 3 Wholesale price differentials, based on 2012 day-ahead wholesale prices.

In the near term, the effect of DSR for this use case is to shift demand from periods of high demand and high prices to periods of lower demand and lower prices. This can result in a reduction in overall wholesale prices. For instance Baringa [3] have modelled a reduction in average wholesale prices in 2030 of nearly 2%[14], based on DECCs pathway alpha for domestic and SME DSR. The marginal value of this use case will also reduce with increasing DSR uptake, as peak prices are flattened by the use of DSR.

On the other hand the use of DSR could also have an upwards effect on average wholesale prices if it is used to reduce wind curtailment and reduces occurrences of negative prices, this is further discussed in section 4.3.2.

While this use of DSR represents a clear value for pure suppliers, for integrated supplier-generators the reduction in wholesale costs could result in a reduction of peak generator margin on the short term.

4.2.2 Balancing

Using on-demand DSR could also enable suppliers to reduce their portfolio imbalance. These savings can be passed on to consumers through lower commodity costs on their electricity bills. The value of DSR for supplier balancing can be represented by the spread between the wholesale price, represented by the Market Index Price (MIP), and the

[14] From 71.5 £/MWh to 70.2 £/MWh

imbalance price which the supplier would incur in settlement for imbalance positions, e.g. the System Buy Price (SBP).

In the value chain analysis presented in Section 5.2, the modelled MIP and SBP prices from the Baringa analysis for the Electricity Balancing Significant Code Review (EBSCR) are used [28].

These are depicted in Figure 5 for 2015 to 2030. In the do nothing scenario, SBP in 2010-2012 ranges from an average of 60£/MWh to maximum 500£/MWh.

In Policy Package One the marginality of cash out prices is increased, while maintaining a dual cash-out structure, and it is assumed that the SBP can increase up to the value of lost load, resulting in an average SBP of 82£/MWh and a maximum of 6000£/MWh (although modelled maximum prices remain significantly lower). For the value chain analysis (Section 5.2), a typical range of 30£/MWh to 80£/MWh is assumed for current conditions, with maximum prices reaching up to 500£/MWh.

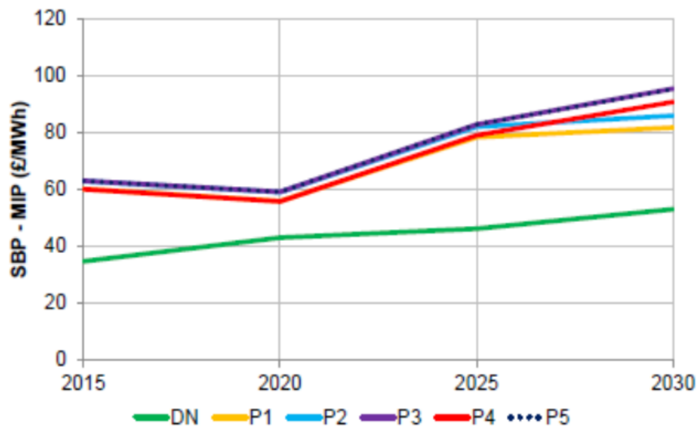

Figure 4 Evolution of average buy side spreads (SBP-MIP) under different policy packages in the EBSCR. Source: Baringa EBSCR [28]

Apart from the cash-out structures, balancing prices are also strongly impacted by the level of intermittent generation and the flexibility available in the generation mix. Analysis by Imperial College [18] indicates the value of DSR for balancing in a scenario with 26GW installed wind generation and for different levels of generation mix flexibility and DSR uptake ranges from 50£/MWh up to 500-800£/MWh, based on fuel and CO_2 costs of holding spinning reserve on conventional generators. The lower end of this range represents the fuel and carbon costs for an OCGT.

4.3 Generator

The potentially highest savings from DSR on the generation side are driven by reducing fuel and carbon costs and reducing the need to invest in peak generation capacity, by shifting demand away from peak periods. These savings are to a large extent captured in the supplier wholesale cost reduction use case and are hence not taken up as a separate use case in the value analysis. Moreover, for existing individual generation plants, especially peaking plants, shifting demand away from peak periods, can also reduce their revenues by lowering the number of running hours. Additional use cases are reducing connection costs and avoiding curtailment.

Shifting peak demand to periods of lower demand can contribute to reducing operational costs of electricity generation, as peaking plants generally have higher operational costs (fuel, CO_2). Additionally, the subsequent increase of base load plant utilisation would increase their operational efficiency (due to higher load factor).

Consistent reduction of system peak demand also reduces the need to invest in peak generation, and thereby reduces system cost.

4.3.1 Reduction of connection costs

As discussed in the DNO use case on reducing connection costs, part of the benefit of deferred network reinforcement required for a new connection, accrue directly to the generator. However, generators could potentially also benefit from reduced capacity charges even if no capacity reinforcement is required. In this case benefits are however, significantly lower.

As previously presented in the equivalent use case for DNOs, upwards controllable on-demand loads and day-in day-out loads on the same circuit can potentially support deferral of these reinforcements.

4.3.2 Avoided curtailment of generation connected to distribution network

On heavily generation loaded network sections, DSR providing a controllable increase in demand could potentially be used to avoid generation curtailment, by increasing local demand. For this use case the responsive load needs to be sufficiently controllable and reliable. The DSR resource and generator also need to be co-located behind the same network constraint. Especially for distributed wind at HV level the extent to which generation and sufficiently controllable demand are co-located may be limited.

The cost of curtailment is equal to the foregone wholesale price of electricity and other generation related incentives. For distributed renewable generation this is typically in the range of 40-140£/MWh [2] [4].

By increasing demand in periods of high wind and low demand, periods with low or negative prices may be reduced, with an upwards effect on average wholesale prices. Modelling by Poyry for use of DSR to absorb wind in low residual demand periods shows an increase in average wholesale price from £76.38/MWh to £78.23/MWh for 2030 simulations [5].

4.4 Transmission system operators (TSO)

4.4.1 Ancillary services

The TSO is responsible for balancing demand and supply after gate closure[15]. In order to fulfil this obligation it takes actions in the balancing market and procures ancillary services. The procurement of ancillary services ensures there is sufficient capacity and responsiveness available to the TSO and reduces price risk in calling balancing actions. The ancillary services most relevant to the CLNR interventions are the Short Term operating Reserve (STOR), Fast reserve (FR) and Firm frequency response (FFR). These ancillary services require on demand controllable load.

Ancillary services can be provided by generation or controllable demand. Currently demand side response contributes ~8% of frequency response, 38% of fast reserve (at night, 0% during the day) and 45% of STOR, as reported by National Grid[10]. Demand side contributions to STOR are however, mostly provided by embedded or back-up generation and only 5% of STOR capacity is due to load reductions[16].

If DSR can provide lower cost ancillary services than conventional generation, these cost savings can reduce Balancing Services Use of System charges (BSUoS) which are passed on to customers[17].

STOR

Services for additional active power through generation or demand reduction are used to balance unforeseen mismatches in supply and demand. These additional power sources which are available to National Grid are referred to as *Reserve* and comprise synchronised and non-synchronised resources. National Grid procures the non-synchronised requirement primarily through Short Term Operating Reserve (STOR).

STOR is procured via competitive tender with providers expected to deliver for a minimum of two hours and a minimum capacity of 3MW (can be aggregated) and no later than 4 hours after instruction, receiving in exchange availability and utilisation payments for their services. A summary of STOR related market data is presented in Table 2.

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[15] Contracts can be struck in the wholesale market upto an hour before the settlement period which the contract is for. This cut-off is termed “Gate Closure”.

[16] Overview of National Grid’s Balancing Services’, National Grid presentation during Ofgem day, 20 November 2012; Available at: https://www.ofgem.gov.uk/ofgem-publications/56997/national-grid-presentation-demand-side-response-event-autumn-2012.pdf

[17] Current BSUoS charges ~1.5 £/MWh (average over 2011-2013)

Table 2 STOR market data (2010/11; 2012/13) [1]

	2010/11	2012/13
Availability price (£/ MW / h)	9.1	7.4
Utilisation price (£/ MWh)	252	202
Average utilisation (h/yr)	40-50	50-70
Average MW procured[18]	2,570	3,178
Average availability provided (MW)[19]	2,045	2,344
Availability payments (£million)	75	66
Utilisation (GWh)	100	167
Utilisation payments (£million)	19	26
Average cost (£/MWh utilised)[20]	940	551
Average cost (£/kW/yr)	39	31

Fast Reserve

Fast Reserve is used, in addition to other balancing services, to control frequency changes that might arise from sudden, and sometimes unpredictable, changes in generation or demand, such as TV-related pick-ups (e.g. the end of a popular programme), unpredictable short term demand increases (changes in weather) or loss of operational systems.

Fast Reserve must provide rapid and reliable output of high levels of active power through the activation of generation plants or demand reduction following receipt of an electronic despatch instruction from National Grid. Fast Reserve is the quickest acting reserve service and has to be provided within two minutes of instruction, with a minimum ramp-up and down rates of 25MW/minute, with a minimum capacity of 50MW and with the capability to be sustained for a minimum of 15 minutes. In exchange of the provision of this service, the DSR supplier receives a service payment (£40-50k/MW/yr)[21].

[18] Volume weighted by season hours
[19] Peak moment per day between April 1st - March 31st
[20] Grey fields calculated from the NG data, average cost in £/MWh is based on MWh utilisation
[21] 2009

Firm Frequency Response

Firm frequency response is an automatic change in active power output or demand in response to a frequency change and this service compliments mandatory frequency response. Services are procured through a competitive tender process, where tenders can be for low frequency events, high frequency events, or both. Providers of this service must operate in a frequency sensitive mode for dynamic response or to change their capacity level for non-dynamic response and deliver a minimum of 10 MW (can be aggregated).

The cost of this service (2011) was £50-60 k/MW/yr (availability, holding and utilisation).

4.4.2 Transmission network peak management

Similar to the DNO, the TSO can use DSR resources to reduce system peak demand. Both day-in day-out and on-demand during winter periods could support the deferral of network reinforcement. The value of system peak demand can be represented by the corresponding TRIAD charges. These are in the range of £10-30 k/MW (Scotland – South West)[22]. The corresponding contribution to network peak load reduction by individual providers of response also depends on the diversity of their response. On-demand DSR is assumed to have no diversity, i.e. response is delivered for specific requirements, while for the contribution of static Time of Use tariffs the diversity of customer response reduces their effective individual contribution. The summary in Figure 2 represents provision by residential tariff customers and includes a 0.2 coincidence factor[23].

4.4.3 Capacity services

Capacity market

The capacity market will be launched in the winter of 2018 and is intended to ensure security of electricity supply. Energy assets that do not receive incentives under other schemes can bid competitively for the provision of capacity during winter peak periods and can operate in the electricity market in addition to that. The capacity market will provide a steady, predictable revenue stream on which capacity providers can base their future investments. The value that DSR could capture in the capacity market is expected to be in the order of £20-40/kW/yr.

[22] TRIAD charges correspond to the three half-hour periods with the highest demand on the electricity system, where electricity suppliers are charged higher rates under the TNUoS

[23] Typical coincidence factor (i.e. inverse of diversity) for 100 customers as reported by Imperial college [18].

Supplemental Balancing Reserve (SBR) and Demand Side Balancing Reserve (DSBR)

During the second half of 2013, two temporary new commercial balancing services were created to safeguard security of supply in the near term before the capacity mechanism is established to support capacity investments, the Demand Side Balancing Reserve (DSBR) and the Supplemental Balancing Reserve (SBR).

DSBR is targeted specifically at large energy users willing to reduce their demand (or provide backup generation) during winter weekday evenings between 4 and 8 pm. SBR is targeted at keeping power stations in reserve that would otherwise be closed or mothballed.

DSBR has been deemed necessary for this coming winter of 2014/15, and a volume of 318 MW[24] has been tendered for. Providers can bid in both an optional set-up payment and a utilisation payment. With the bounds for the tender being set at £0-10,000/MW for the set-up payments and utilisation payments bounded by the value of lost load (£500-£12,500/ MWh)[20.]

[24] National Grid website. Available at: http://www.nationalgrid.com/NR/rdonlyres/D977D764-D856-492D-9E17-12B36299CF73/63454/DSBRMarketInformationfor1415ContractsFinal260914.pdf

4.5 Use case requirements

	DNO			SUPPLIER		GENERATOR				SYSTEM OPERATOR			
	Peak load management	Post fault management	Reduce connection costs	Reduce wholesale cost	Reduce balancing costs	Reduce opex	Reduce peak capacity	Reduce connect. cost	Avoid curtailment	STOR	FFR	FCDM	FR
Location specific	yes	yes	yes	no	no	no	no	yes	yes	limited	limited	limited	limited
Frequency	Peak periods (typically nov - jan)	Specific events	Peak generation, peak demand for future load connection use	All year, daily	All year, daily	All year, daily	Mainly winter peak period (also periods of variable demand)	Peak generation	Peak generation	Available >3x/wk	Continuous	10-30 times/yr	Mostly in peak
Min. size (MW)	-	For trials: 0.2	-	-	-	-	-	1-10s MW	1-10s MW	3	10	3	50
Duration	2-4h	4h/day – 14 days	Typical peak	~2 h	~1-2 h	~2 h	system peak	Typical peak	Typical peak	>2h	secs to mins	30 min	15min
Dispatch notice	Annual – quarterly (<4h,)	(1/2h)	Forecast window	1-7 days	1/2-24h	1-7 days	1-7 days	Forecast window	Forecast window	4h	no notice	2sec	2min
Declare availability	Long term – time to deploy alternative	Long term –time to deploy alternative (one week ahead in operation)	At start	-	24h	-	-		Forecast window	Week ahead	Week ahead	24h/day	Week ahead
Response guarantee	Moderate	High	Low	Low	Low	Low	Moderate	Low	Low	Moderate	High	High	High
Suited DSR type	Static Dynamic On-demand	On-demand	On-demand	Static Dynamic On-demand (high frequency)	Dynamic On-demand	Static Dynamic On demand	Static Dynamic On demand	On-demand	Dynamic On-demand	Dynamic On-demand	Dynamic On-demand	Dynamic On-demand	Dynamic On-demand

SECTION 2 – CLNR Interventions and the DSR Value Chain

5 CLNR interventions

The CLNR DSR trials included:

- Static DSR with residential and SME Time of Use tariffs.
- Dynamic DSR with residential PV customers utilising within premises balancing.
- On-demand DSR in the form of bilateral contracts with I&C customers and also the direct control of residential washing machines.
- Electrical Energy Storage.

5.1 Trial overview and key results

5.1.1 Static DSR

CLNR has successfully trialled a residential static Time of Use tariff (CLNR test cell 9a). The ToU tariff reflected the value of shifting demand to provide peak reduction for network operators and wholesale cost reduction for suppliers. The supplier passed on the ToU incentives through the electricity bill, and settled these customers against adapted profile class 1 Standard Settlement Configurations.

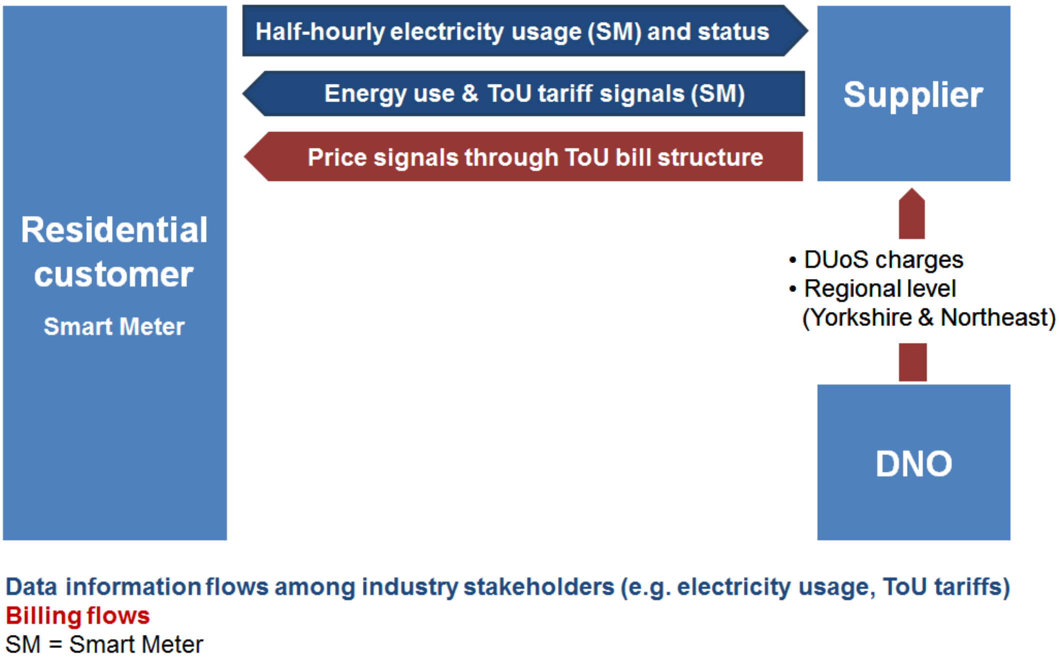


Figure 5 Schematic of trial setup

The setup of the trial is schematically shown in Figure 5 above. Through the smart meter infrastructure the three rate price signals (Table 3) are sent to the customers and half hourly consumption is reported back to the supplier[25]. The tariff offered by the supplier reflects the potential cost savings from peak demand reduction for the network operators (DNO & TNO) through 3-rate DUoS charges, as well as wholesale purchase cost savings to the supplier [43]. The key metrics for these cost drivers are peak demand reduction and consumption shifted from peak price periods to off-peak price periods.

Key results

Compared to the baseline control group (smart meter customers without CLNR interventions), the customers on the ToU tariff were found to have:

- Lower electricity kWh consumption during peak periods by 1.5% - 11.3%. This is in line with our qualitative research where customers claim changing time of use of some appliances.
- Lower average kW peak power demand during peak periods, between 3.2% - 12.5% when averaged throughout the year and across all customers.
- On average, customers showed a lower maximum half-hourly peak demand (between 2.1% - 10.3% lower) during the peak period. However, at the time of greatest system peak demand – a single half-hour in the year - there was no (statistically significant) difference in demand observed.
- However, at the time of greatest system peak demand – a single half-hour in the year - there was no (statistically significant) in the mean peak demand observed.

For DNOs the lower annual mean peak period demands, compared to the control group, show the potential of such tariffs to contribute to network peak demand reduction. However, a critical issue for DNOs is the max peak demand reduction on the day of greatest network stress, which was not lower than the control group in the trial.

For suppliers the reduction in electricity consumption in the evening peak periods shows the potential to reduce overall wholesale purchase costs. The total annual energy consumption reduction was 0.8% lower than in the control group, but this difference is not statistically significant.

The trials showed that a sizable proportion of customers are able to shift their energy use and understand that ToU tariffs can help them save on electricity bills. ToU tariffs enable the reduction of network and generation costs, with the potential for some of these savings to be passed on to consumers.

In the SToU trial, 60% of customers have saved money, with an average saving of £31 over the period and a maximum saving of £376. 40% of customers have paid more on the Time of Use tariff than they would have paid had they been on British Gas' Standard tariff during the period, with an

[25] Only daily register reads were used for billing purposes. Sending HH data back to the supplier is optional and will be managed by DCC in future.

average compensation due of £25 and a maximum of £191. Participants in this trial were told that they were protected from an increase in electricity bills, which were capped at the level they would have been at under a flat-rate tariff. An enhanced level of response might be expected in a trial without a “safety net”.

The extent to which customers benefit from a SToU tariff depends on both their ability to shift their electricity consumption, as well as their original consumption profile. When SToU tariffs are voluntary, it is likely that only those customers who are able to save money will take up such a tariff. These are the customers that end up with lower peak consumption, either because of their existing consumption profile or behaviour change. Customers with relatively high peak consumption and limited ability or willingness to shift consumption, may stay on a flat tariff. This potentially limits the impact of a ToU tariff.

In addition, customers may vary in the extent to which they are able to adapt their consumption profile. The CLNR social science studies suggest that a lack of flexibility is created through wider social ‘structures’ and household economies over which individual households may have little control. These studies furthermore found that some households are able to be more flexible than others, particularly those with fewer or less rigid commitments to work and family and those with a higher degree of know-how about appliances are more able to be flexible in their energy use. Testing of the marginal distributional response to the ToU tariff was limited to housing tenure (renter/home owner) and the presence of dependents in the household. It was found that home owners and households without dependents were more likely to respond to the ToU tariff compared to renters and those with dependents.

Table 3 CLNR ToU tariffs Intervention trial details

Rate	Time period	Per kWh adjustment
Day	7.00 – 16.00, Mon-Fri	-4%
Peak	16.00 – 20.00 Mon-Fri	+99%
Off-peak	20.00 – 7.00 Mon-Fri; Sat; Sun	-31%
	Daily standing charge	16p

A group of approximately 600 customers were involved in the trial for over a year. Customer appetite for this proposition was very high, with 40% more customers consenting to join than the target of 600, with an “opt-in” scheme [20]. The trial recruitment was carried out as much as possible as a normal marketing campaign similar to other products. However, trial participants were offered vouchers (£50 to join, £50 to complete and another £50 in the end to extend) and were protected from financial loss by being reimbursed at the end of the trial if the trial tariff resulted in a higher electricity bill compared to a British Gas standard (flat) tariff. Furthermore, the trial was promoted as part of the CLNR project and communication material was branded “CLNR”. In addition, such a novel product has the potential to over represent early adopters.

SME engagement

The CLNR trials showed that engagement of SMEs in DSR propositions and response to DSR signals can be successful. However, the difficulties in recruitment also showed that SMEs were the most challenging group to engage in DSR propositions. Key challenges in engaging SMEs in DSR propositions are the large variation in business types, applications and operational demands. On the other hand CLNR has been successful in characterising generic applications and usages with SMEs that could be suited to provide DSR.

The recruitment was particularly challenging for a trial that combined a three rate ToU tariff with restricted running hours during the super peak period. Over 20,000 SMEs were approached, and initially 350 were willing to participate. However, by the start of the trial, only two businesses remained willing to participate. Difficulties in securing SMEs involvement in this trial were driven by the risks perceived by SMEs around the impact of load reduction on the daily running of the business:

- They are service providers and the hours and the type of process used are controlled and driven by the service users, and there is little or no movement on these time frames from the users.
- The need to capture passing trade in the case of shops, restaurants, hotels and public houses, as well as retaining clients, requires flexibility in opening times.
- Regulatory concerns are central for a lot of SMEs.

The SME trials included a case study of a hospitality business which combined a three rate ToU tariff with restricted running hours. The SME was only willing to participate if they were provided with an override function of the direct control signal. This may be a necessary requirement for widespread rollout of DSR contracts in the SME sector.

The aggregate demand from SMEs tends to decrease during the evening peak period, as business close. This reduces the ability of SMEs to contribute to network peak demand reduction for DNOs, but they could still contribute to use cases for other stakeholders. Moreover, SMEs still contribute significantly to the overall peak demand, and the heterogeneity of business means that some SME's load profiles overlap with the system peak. In addition, specific loads can be identified, even with SMEs that close business during the evening peak period, which could contribute usefully to network peak demand reduction. Examples of these appliances identified in CLNR include storage heaters, chillers, fridges and freezers, swimming pool pumps and heaters. Overall, this suggests that parties wishing to procure DSR from SMEs may find it most effective to offer a "menu" of DSR contracts to reflect features of the diversity of loads available from SME customers.

5.1.2 Dynamic DSR

CLNR trialled a form of dynamic response for customers with photovoltaic (PV) solar panels, in which loads would be switched on when the PV panels were exporting electricity. In one test cell the In Home Display (IHD) provided real time notification when PV generation was exported, allowing customers to manually activate appliances to increase self-consumption. In the second test cell, an immersion heater was turned on automatically when PV generation was exported. Figure 6 presents the trial set up for the two test cells involving solar PV panels (TC20 manual and auto).

Comparison of the electricity demand for the properties with PV and an in home display to a control group with only PV did not show statistically significant differences in the amount of PV generation consumed in the premise, or network peak generation. Customers did however indicate in interviews that they adapted their demand in response to the IHD signals.

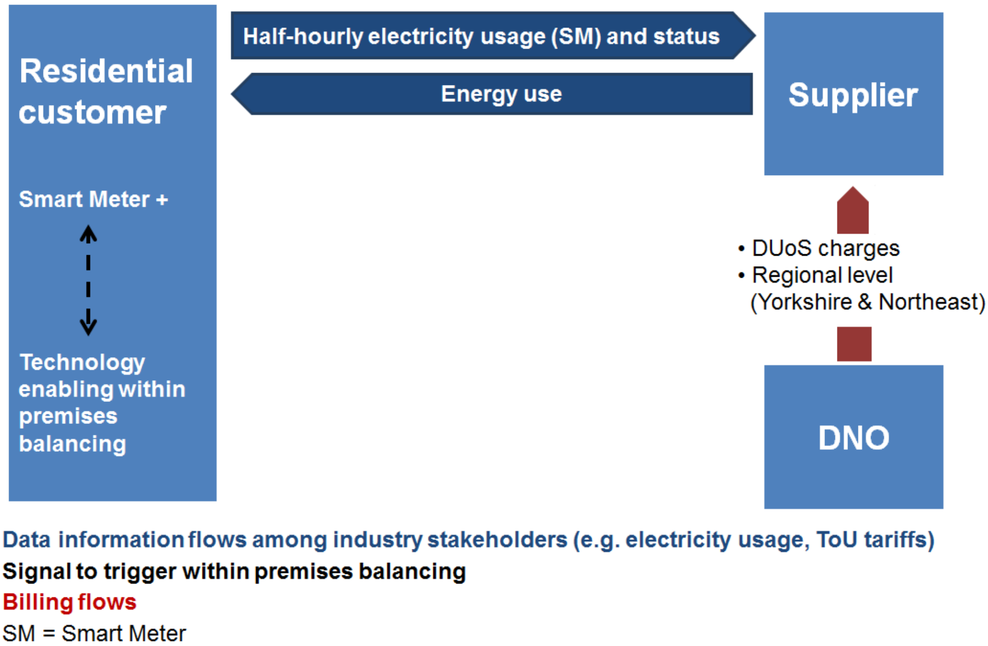


Figure 6 Schematic trial set up for CLNR test cell 20 manual and auto

5.1.3 On demand DSR

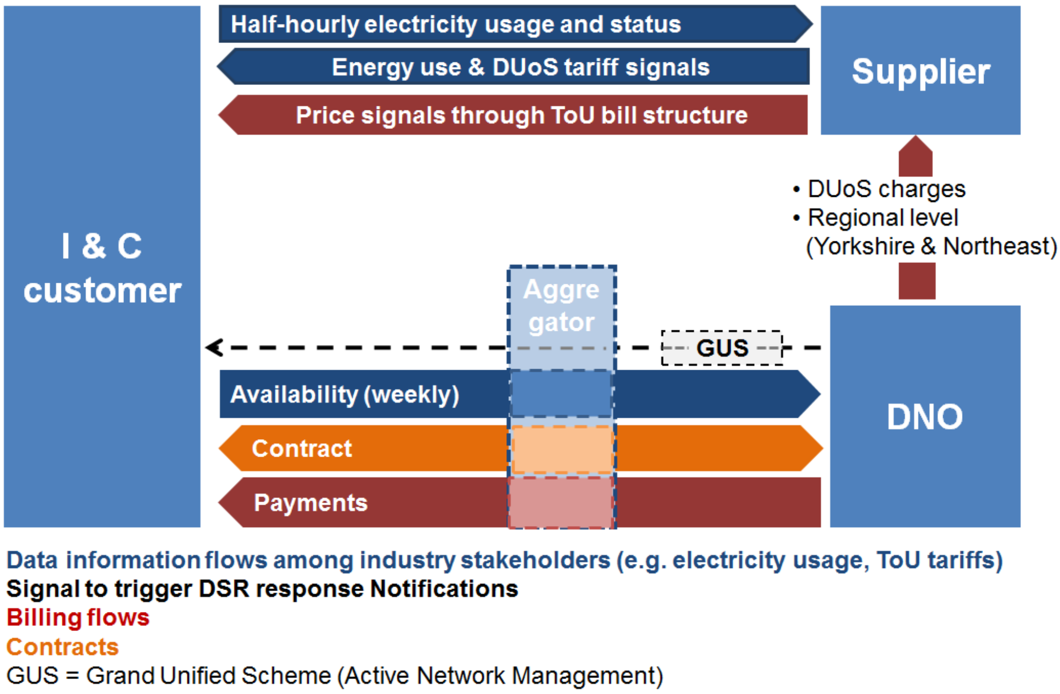
CLNR has trialled various forms of on demand DSR; with I&C customers utilising standby generation and load reduction when called by the DNO and also with residential customers via the direct control of washing machines.

In test cell 18 the I&C customers provided on demand DSR to mitigate thermal constraints on a primary transformer. In the trial the DSR resources were called upon in response to a simulated thermal constraint situation. Different methods to call for response were used, including automated text message and Modbus over VPN sent through the projects' active network management system. The setup of the trial is depicted in Figure 7.

This trial successfully showed:

- DSR service procurement by a DNO from I&C customers on commercial contracts, through aggregators and directly with customers.
- I&C customer willingness to adopt different contract and payment structures for the provision of post-fault network management through generation support, demand reduction and demand shifting.
- Signalling for DSR using the active network management system, both through aggregators and directly with customers.

- Load reduction at the primary substation at moments of simulated stress, resulting from the



provision of DSR.

Figure 7 Trial setup for I&C DSR trials in test cell 18 (with and without aggregator)[26].

During the spring 2014 I&C trials three types of contract types were offered, and two of them were adopted by customers:

- Standard Aggregator.
- Aggregator 10-day average.
- Aggregator floor.

Standard Aggregator contract – provides availability (£/MW/h) and utilisation (£/MWh) payments, similar to STOR contracts. The delivered response is determined by subtracting the half hourly metered consumption during the DSR event from the site's metered consumption the half hour immediately preceding the event.

Aggregator 10-day average contract – similar to the above contract, with availability and utilisation payments, where the response delivered is calculated by subtracting the site's metered consumption during the DSR event from the site's baseline load. This is defined as the arithmetic mean (average) of the site's measured demand, in MW, for each half hourly period in the Availability Window falling within each of the immediately preceding ten business days, excluding days when instructions have been issued by Northern Powergrid. None of the I&C providers opted for this type of contract.

[26] Not all customers had price signals through the ToU bill structure. Visibility of the DUoS element depends on supplier tariff offering

Aggregator floor contract – provides a daily rate (£/MW/day). A maximum demand ("floor") is agreed which the site must not exceed during the DSR event. The *response delivered* is calculated by subtracting the agreed maximum demand during the DSR event (floor) from the agreed average demand; which is the average demand during the availability window[27], only for periods during which demand response is not provided, and is specified in the contract.

For the DNO a combination of availability and utilisation payments provides both assurance of availability and an incentive to provide response when required. Compared to daily charge contracts the cost will be either lower or higher, depending on how frequent the resources need to be called, On the other hand, daily charge contracts are simpler to operate and validate by the DNO, and their costs are predictable.

The payment structures in these contracts were based on an estimate of the frequency with which these DSR resources would be called. Subsequent fault rate analysis indicates that for post network fault management utilisation would be on average three times a year for a period of four hours, with availability required for 83 days throughout November to February for four hours per day. The actual requirement to call DSR for network purposes may vary significantly from year-to-year. Very infrequently calls for response up to 10 times could be required [12]. Similarly very low call rates would be expected for some years. If DSR payments contain a large fraction for utilisation, this could represent a commercial risk in the arrangement for customers.

The DSR resources that participated in the trial had an average reliability of availability of 50% and a success rate when called of 94%. This implies that a portfolio of resources is required to guarantee a firm response when called, and reduces the value that can be assumed to be provided per resource. These reliability figures will significantly impact the F-factors that can be attributed to these DSR resources.

The recruitment of customers for the CLNR trials showed that one of the key challenges is procuring sufficient co-located DSR capacity in specific areas of the network. In the trial, DSR providers were required to individually meet the DNO use case requirements as an insurance product for post-fault management at primary substation level. This reduced the number of customers able to participate in these schemes[28]. A solution to this issue is to use a portfolio of customers to deliver the DNO's requirements, each contributing towards the total requirement.

Three different types of DSR resources have provided DSR in these trials, meeting or exceeding the contractual requirements for response requirements. All response providers delivered a response within the required half hour notice period and some were capable of responding within minutes. Generation support, the majority of providers, maintained response for a period of 2-4hours. A refrigeration facility providing 0.6MW demand reduction also successfully delivered sustained load shedding for periods of up to 4hours. A 5MW gas production and distribution customer provided DSR services by load shifting. This customer outperformed in the delivery of its contracted services,

[27] Agreed times in the contract in which the DSR provider shall be prepared to deliver Demand Response

[28] In the I&C survey conducted in [11] indicates an average of 25 I&C sites were available per primary substation, with only 9 on average matching the trial criteria to deliver DSR (>200kW)

shifting a capacity of 10MW over a period of 8hours (compared with the contracted 5MW for 4hours). Table 4 presents a summary of the I&C trial results.

Table 4 I&C trial results overview

PARAMETER	TRIAL RESULTS
Capacity reduction per site (MW)	0.3 – 5
No. I&C customers providing activation of embedded generation	12
No. I&C customers providing load shedding	2
Contracts adopted: (%) standard / (%)floor / (%)10 day	71 % / 29% / 0%
Required response time (min)	30
Success rate when DSR called[29]	94% (spring 2014 trials)
Reliability of availability (%)[30]	50% (spring 2014 trials)

The maximum a DNO would be willing to pay for these DSR resources is equal to the annualised alternative reinforcement costs minus the costs for implementing and operating the DSR resource. This value furthermore depends on the confidence factor (F factor) of the DSR resource, and the period for which network investments are deferred.

Figure 8 represents the maximum DSR prices for which DSR can be a competitive alternative to conventional network reinforcement costs, based on a typical HV network reinforcement case for Northern Powergrid's network (Table 5). These values are lower than the yardstick values in section 4.1.1., which represent more of an upper bound. Utilisation and availability payments or daily payments are based on an availability window of 4 hours for 83 days/yr and a utilisation of 3 DSR calls/yr for a 4 hours period.

The value of DSR resources also critically depends on whether conventional reinforcements are deferred or completely replaced. Figure 8 shows a 26% decrease in value if an investment is deferred for 5 years, rather than completely avoided.

Although the value of DSR is lower if an investment is only deferred for a few years, the temporary DSR solution also represent an option value, as more optimal solutions could be implemented a few years later. Furthermore a DNO could be able to pay higher rates for DSR in the first few years. Network investments are carried out in discrete capacity expansions, taking into account future load

[29] Between winter 2012 and spring 2014 there was a total of 47 DSR calls (of which 4042 were successful)
[30] There were 94 successful declarations of availability out of 181

growth, meaning there is over capacity in the first few years, A DSR solution however, could be procured for the exact capacity required, which then defers an investment representing a higher capacity.

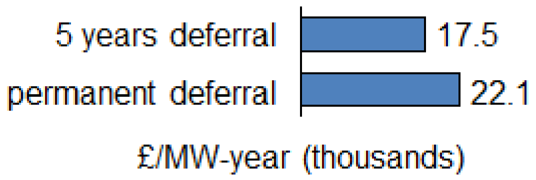


Figure 8 CLNR trial average contract payments for test cell 18, I&C customers (refer to Table 4)

Table 5 Assumptions for DSR ceiling prices calculation

Assumptions	Value
Cost of conventional lowest cost alternative solution (£million)	1.5
Cost of provision of DSR controllers and back-office work (£million)	0.1
Capacity of DSR needed reinforcement deferral (MW)	2
Confidence factor (%)	75
Discount rate (%)	4
Days of availability (for 4h periods)	83

Residential direct load control

The CLNR trials with direct controlled washing machines and heat pumps showed that these can have a statistically significant contribution to peak demand reduction. This has been successfully demonstrated on the CLNR project despite the inevitable technical issues associated with the first UK application of these technologies.

A schematic of the trial set up is presented in Figure 9. The trial participants were on a flat tariff[31], and a broadband communication was established through a router, enabling communication with a data monitoring and control system. The direct control washing machine trial encountered problems with the DSR communications technology which limited the number of signals received by customers. For future development of these applications the reliability of the communications is critical in realising a reliable response.

[31] The participants in the direct controlled washing machine trial received this appliance, worth approximately £1000 for free, this should be taken into account in interpreting the trial responses.

The washing machine trials showed that, of the times when a user was using or planning to use a washing machine that received an instruction not to run, they delayed the cycle on 30% of occasions. Although this success rate is not very high, it does show DSR having an effect on behaviour: on almost a third of occasions when a user attempted to start a cycle on a machine displaying the interruption message, they delayed it. Moreover, the trials also showed that peak time washing machine consumption is significantly lower on days that a DSR signal is sent. However, the magnitude of the decrease in power (perhaps an average 25W per consumer signed up to DSR at the 6pm peak) is relatively low compared to overall peak values. This is partly due to washing machines not being on for the majority of the time and communications issues resulting in customers not receiving the signal.

The CLNR trials showed that having an override function on direct load controlled appliances did not materially impact the reliability of response, i.e. it wasn't used often. This is encouraging, as the lack of control over one's own appliances is often seen as a barrier for customers to adopt direct load control interventions. These results show that when an override is provided this doesn't necessarily impact the value for the DNO significantly, and could give reassurance of control to customers.

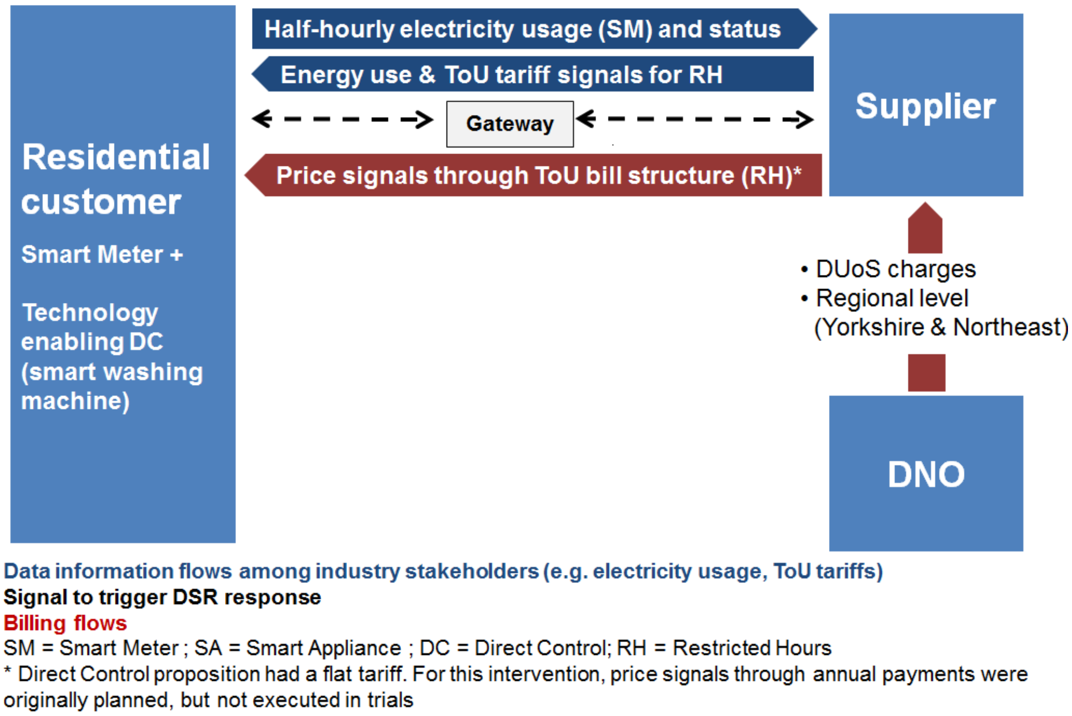


Figure 9 Schematic set up of trials of restricted hours tariffs and direct load control propositions in homes with smart washing machines (test cell 10 wet white goods and 11 wet white goods)

5.1.4 Network electricity storage

In CLNR six EES assets of varying capacities have been installed and operated in trials, three batteries with a rating of 50kVA/100kWh, two 100kVA/200kWh batteries and one with a capacity of 2.5MVA/5MWh. These assets were deployed, owned and operated by Northern Powergrid. The CLNR project's EES trial is unique for two reasons; the size of the largest battery; and for the first time the devices and networks they are on are being monitored through an Active Network Management (ANM) control system, developed for CLNR.

The electricity storage trials in CLNR have focussed on the network management and technical aspects of storage rather than the commercial arrangements. The batteries have been sited on Northern Powergrid's network to understand how the technology works across different network areas. The locations are chosen such that combined they offer a representative sample of 80% of the UK's total electricity distribution network. Based on the work in CLNR, a number of papers on the role of EES for network management purposes have been published by Newcastle University [42].

The 5 MWh, 2.5 MW battery was connected to the 6.6kV busbars at a primary substation in a suburban location in the North of England. This asset was used to demonstrate peak shifting and voltage control under various network conditions. In particular, if the double circuit 33 kV infeed were lost, customers would lose supply, possibly for extended periods without the use of the battery. In these circumstances it would be possible to support some customers, but not all, at times of peak demand via the lower voltage 6.6 kV network. Similar to the use of DSR for fault conditions, the expected benefits of the electrical energy storage use case are a function of the relatively low probability of the (n-2) event of simultaneously losing both 33 kV infeed circuits to the primary substation.

Generally, EES can contribute to the operation of the future electricity system in the following areas:

- Distribution network voltage control.
- Distribution network power flow management.
- Distribution network system restoration.
- Increased distribution network security and reduced fault disconnections.
- Support the connection of low carbon load technologies and distributed generation.
- Wholesale purchase cost optimisation (price arbitrage).
- Provide ancillary services.

5.2 Distribution of value across the value chain

This section provides an illustrative overview of the relative distribution of value between different stakeholders when DSR resources are accessible for multiple use cases by multiple parties.

5.2.1 Static DSR

Figure 10[32] shows a total value (excluding potential costs for operating ToU propositions) of some 23£/yr/customer for the SToU, based on the average customer results from the CLNR trial (as presented in section 5), including a 0.8% overall consumption reduction. The trials showed a large spread in value realised by different households, with the majority of the households (60%) realising an overall saving, with an average saving of £31 over the period and a maximum saving of £376.[37]. The difference between the average and the maximum saving is significant. In the future, developments like home and appliance automation, feedback from IHD or VHD could support realising further savings.

[32] Based on the average peak period peak demand reduction, rather than the reduction on the day of greatest network stress.

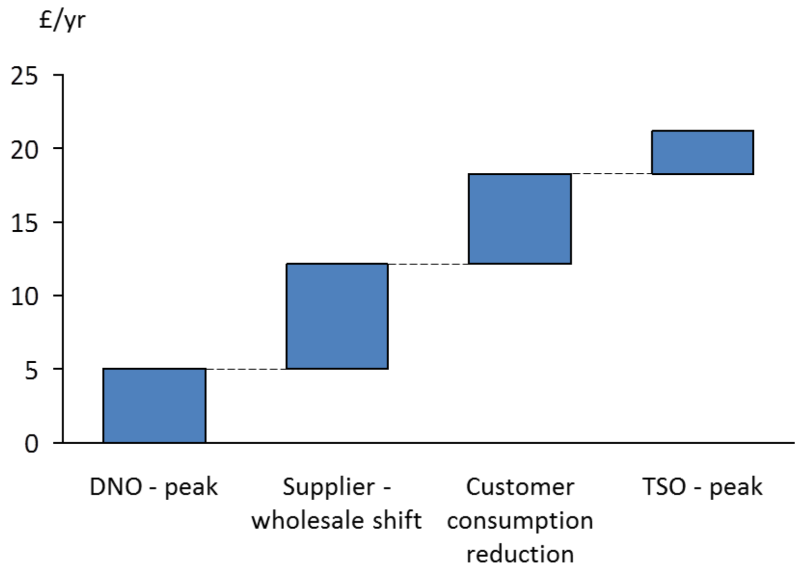


Figure 10 Annual value of SToU, based on the typical values presented in section 4 and the average customer results for CLNR, including 0.8% total consumption reduction

The value to the DNO and supplier of this intervention are similar, as has been shown in analysis by Baringa [3]. However, the ability to offer competitive propositions to customers represents an additional value to the supplier. Moreover, cost reductions from the intervention can be captured to a large extent by the supplier, subject to the barriers discussed in section 4.2. For the DNO on the other hand, there are several constraints for the intervention value to be realised. Sufficient scale and reliability of response is required, and it needs to be available at otherwise constrained locations in the network. This suggests that the total annual benefit that DSR can provide could be much higher for suppliers than for DNOs.

The value of DNO peak demand reduction in Figure 10 is based on the value represented by peak demand reduction at the LV level, where response is required day-in-day-out throughout the peak periods.

For the TSO peak demand reduction, customers are assumed to provide response day-in-day-out throughout the winter period. On a dynamic tariff however, response would only be required for peak periods, which are relatively predictable (similar to TRIAD management). This significantly reduces the number of hours that response is required and increases the per event value to the TSO.

For these different benefits to be reflected in a static time of use case, the local demand peak, national demand peak and price peak periods need to be aligned. At the moment this is usually the case as they all align with traditional peak times. With increasing intermittent generation, and clustered uptake of low carbon technologies (electric vehicles and electric heating), these cost drivers may start to diverge in terms of the times and locations that the DSR services are of value.

On the other hand, with dynamic incentives, these flexible loads can be used to help balance generation and demand at different system levels. SToU tariffs are therefore expected to be useful over the next price period, but their ability to capture different cost reduction drivers may diminish with increasing intermittent generation. Analysis by Baringa [3] shows dynamic ToU capturing higher incremental benefits compared to SToU after 2025 in most scenarios.

Cost

The key costs to implementing static time of use tariffs are smart meter infrastructure, billing and IT systems, communication and customer interactions. The type of systems that would be required for the interventions trialled in CLNR are being implemented, and are therefore not regarded as additional costs. Similarly, marketing and acquisition costs for suppliers are not assumed to be any different than for other commercial products, and are not regarded as additional costs.

5.2.2 On demand DSR

DSR from on demand DSR (including direct control) is suited for most use cases and can, in principle, be provided to multiple stakeholders. The cost drivers for many use cases are however different, have varying value and are not always compatible. The annual value of providing multiple[33] use cases is presented in Figure 10 for two situations. In the first situation the DSR provider is able to provide both the network and also the supplier and TSO use cases, whereas in the second situation the system operator use cases, i.e. provision of ancillary services, preclude combination with network operator use cases, i.e. TSO peak management and DSO post fault management. In practice, even if a DSR provider can serve multiple use cases, their individual value could be reduced (for example because of incompatibility of use at certain times). For on demand DSR the payment capacity per unit of provided response is a key parameter determining the strength of incentives that different stakeholders are able to offer. The relative value range of different use cases is depicted in Figure 13[34].

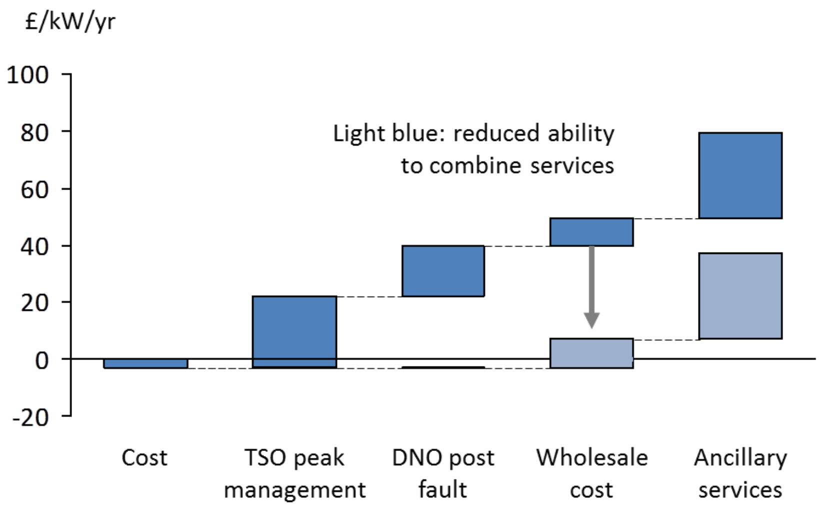


Figure 11 Annual value of I&C on demand DSR

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[33] Providing DSR services to more than one party

[34] The DNO post fault management use case value on a kWh basis appears very high, because of the limited number of utilisation hours (12 per year), the availability requirement (some 83 days per year) are not taken up in this calculation.

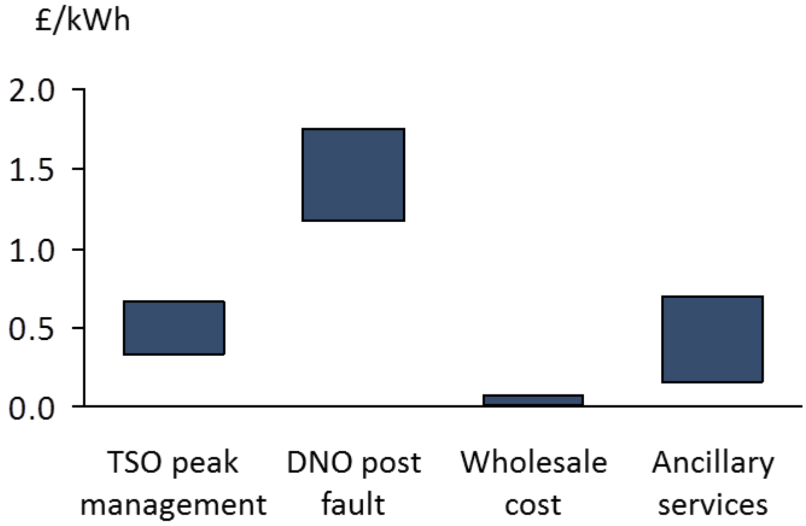

Figure 12 Relative value of use cases per utilisation of I&C on demand DSR

The TSO contracting for availability to provide reserve services and the DNO having options on DSR resources for post fault management are complementary uses. Neither is using the resource regularly and the likelihood that both would want to call on the DSR resource simultaneously is low.

Further use can be made of the fact that the TSO need is at a system level, while the DNO need is localised. Having a larger portfolio of resources allows both requirements to be served, with less impact on the value that can be captured for each use case.

Supplier use cases such as portfolio balancing or wholesale cost reduction are not yet taken up in this framework. It can however, be expected that wholesale cost reduction is relatively compatible with TSO and DNO use cases. Although the revenue that can be captured from supplier use cases may be diminished as those use cases generally coincide with high demand and price periods, and DNO and then TSO use cases may be prioritised, if the hierarchy of the ENA shared service approach would be extended, this is further discussed in section 6.1.2 .

The provision of ancillary services and transmission level peak reduction are not fully compatible, as their window for use overlaps, especially in the winter period. These use cases can be combined however through aggregators or suppliers, but with lower overall value.

Provision of ancillary services and supplier balancing are to an extent mutually exclusive. Either the TSO resolves imbalance by procuring ancillary services, or a supplier uses DSR to avoid imbalance. A supplier could do so if the cost of DSR is lower than the System Buy Price (SBP). Ancillary services are typically more expensive than the SBP. The TSO would therefore typically attach more value to DSR than the supplier would for balancing purposes [5].

Another limiting factor can be the frequency with which such a resource can be called, especially in the case of I&C load shedding if it impacts operations.

Cost

The main cost for the implementation of the interventions trialled in test cell 18 is the active network management system. The unit cost contribution is estimated by Northern Powergrid asset management to be of the order of £50k per primary with 3MW DSR capacity, and £50k for recruitment, contracting and personnel, corresponding to some 3000£/MW/yr. This assumes that for a simple thermal constraint at a primary substation a smart Remote Terminal Unit (RTU) would be installed at the primary. This would monitor the transformer temperature, and call for demand response during a fault if the forecast temperature exceeded a trigger level. As in the CLNR trial this could be done using either GSM/GPRS or a VPN tunnel to contact the aggregator or (other service provider).

SECTION 3 – Barriers and New Commercial Arrangements

6 New commercial arrangements

This section starts with a high level review of the potential future commercial frameworks within which DSR could be deployed. The current situation is characterised as "tariffs and bilateral contracts", which could develop in the near term (within RIIO-ED1) into a "rules based" framework employing multilateral contracts. Beyond RIIO-ED2 and with larger scale uptake of DSR and larger variation of providers and users of DSR, other frameworks could be developed that support more efficient use of these resources. Two options for future frameworks are reviewed: "Distribution System Operator" and "Central Flexibility Market".

In section 7, the current barriers to the deployment of the different CLNR interventions are reviewed, and next steps are identified for the development of these interventions to business as usual options, in the context of the current tariffs and bilateral framework and the near term rules based framework.

6.1 Commercial frameworks

Various forms of DSR are already being used. There is however a high degree of uncertainty regarding how the use of DSR will develop, especially beyond RIIO-ED2. This will be impacted by the uptake of novel DSR propositions and wider changes in the electricity industry. The European Energy Efficiency Directive also states the need to shift policy focus from the potential of technology to actually meeting consumer needs, and specifically highlights treatment of demand response providers (and aggregators) by TSOs and DNOs in a non-discriminatory manner.

The business models for the deployment of DSR may therefore look quite different to today's models in the medium- to long-term. In this section we set out four potential overarching commercial models for DSR. The current situation is characterised as "tariffs and bilateral contracts", this could develop in the near term (within RIIO-ED1) into a "rules based framework" which extends current practices with multilateral industry agreements for greater coordination.

Beyond RIIO-ED2 and with larger scale uptake of DSR and greater variation of providers and users of DSR, other frameworks could be developed that support more efficient use of these resources. Two options for future frameworks are reviewed: "Distribution System Operator" and "Central Flexibility Market".

The three models considered by the EC smart grid task force[35], are also represented within these over-arching commercial models. These models should ensure that consumers and market participants have the necessary information and tools to adequately and effectively engage in the market. They should also limit barriers, and provide equal access for different parties and new entrants, and be flexible enough to adapt to an evolving market.

For each of these models we review their key points, their impact on stakeholders, and how they enable alignment of drivers of different stakeholders. These models are illustrative in nature, and are proposed to provide an overview of the range of possible options, and their relative merits.

[35] DSO, third party market facilitator, and data access point manager

Within these overarching commercial models the various DSR types – static, dynamic and on-demand – could be deployed. In section 00 the current barriers to the development of DSR are reviewed, and solutions and next steps, based on the learnings from CLNR, are discussed in the context of the first two frameworks, as these represent models that could be deployed within RIIO-ED1.

A summary of these four commercial frameworks is provided in Table 6. The table reviews the main aspects and characteristics for each of the frameworks. For each of the four frameworks the key barriers, commercial risks and corresponding market scenario are summarised in Table 7.

Table 6 Summary of commercial framework key points

Model	Key points	Characteristics
Tariffs and bilateral contracts	▪ Evolution of current practices ▪ Specific changes to support uptake of DSR (especially bid sizes and guarantee times)	Tariffs: ▪ DNO sets DUoS to incentivise peak reduction ▪ Supplier responsible to incorporate potential additional value streams in tariffs ▪ DNO has no operational control, and no guarantee of capacity Services: ▪ DNO procures peak reduction on a service basis ▪ DSR provider is responsible for capturing multiple revenue streams
Rules based framework	▪ TSO, DNOs, and possibly suppliers have access to a common pool of DSR resources, with common rules (as in the proposed ENA shared services framework[36])	▪ Sharing pathway[36] when needs are compatible ▪ Alignment pathway[36] determining priority access when needs are mutually exclusive ▪ Limited flexibility to incorporate many different parties and propositions
Distribution System Operator (DSO)	▪ DNO acquires devolved local balancing responsibilities (i.e. takes on DSO responsibilities)	▪ DSO optimises local DSR for distribution and wider system benefits ▪ DNO commercial risk depends on incentive scheme design ▪ DNO centered approach, while DNOs are not necessarily the stakeholder that captures most benefit from DSR. Should not limit access to DSR for other stakeholder
Central flexibility market	▪ Providers make DSR resources available on a market platform ▪ DSR users procure from central place	▪ Could take into account external impacts on other parties ▪ Significant price risk for DNO

[36] Further explained in section 6.1.2

Table 7 Summary of commercial framework assessment

	Tariffs and bilateral contracts	Rules based framework	Distribution System Operator (DSO)	Central flexibility market
Barriers	Limited ability for DSR providers to deliver to different stakeholders	limited barriers – development relies on industry collaboration	Significant regulatory changes to role of DNO and TSO	Extensive market and potential regulatory changes required
Commercial risks	Low commercial risk for DNOs	Low commercial risk for DNOs	DNO commercial risk depends on incentive scheme design	Market price exposure for DNOs
Market scenarios and overall efficiency	Potentially complex contractual arrangements for DSR providers offering multiple services Most limited in potential to optimise across different use cases	More challenging when many parties are involved and DSR needs are dynamic and drivers diverge	DSO role could evolve with increasing uptake of Low Carbon Technologies and Distributed generation at the distribution network level	Specifically suited with large uptake of DSR and when there are significant needs for flexibility from distributed sources at all system levels

6.1.1 Tariffs and bilateral contracts

The Business As Usual model represents potential gradual evolution of current practices. In tariff type propositions the DNO incentivises DSR providers to reduce peak demand through DUoS charges. Additional benefits to suppliers or TSO could be rolled up in tariffs, as long as the drivers for the different stakeholder use cases (e.g. local network demand peak, system price peak) are aligned. For service based DSR provision contractual conditions could be adapted to better enable DSR providers to participate, for instance lower minimum capacity requirements and less exclusive conditions. The responsibility to capture multiple revenue streams rests with the DSR provider. Third parties, such as aggregators or suppliers could support this by contracting a range of DSR resources and guaranteeing various service conditions, based on an aggregated portfolio.

The relations between the various stakeholders in the tariffs and bilateral contracts framework are depicted in Figure 13. Procurement of DSR resources is carried out individually and network operator signals for day-in-day-out DSR are passed on to customer through suppliers. Alternatives for procurement of DSR are available also for network operators, especially for on demand DSR from I&C customers, but transaction costs are relatively high.

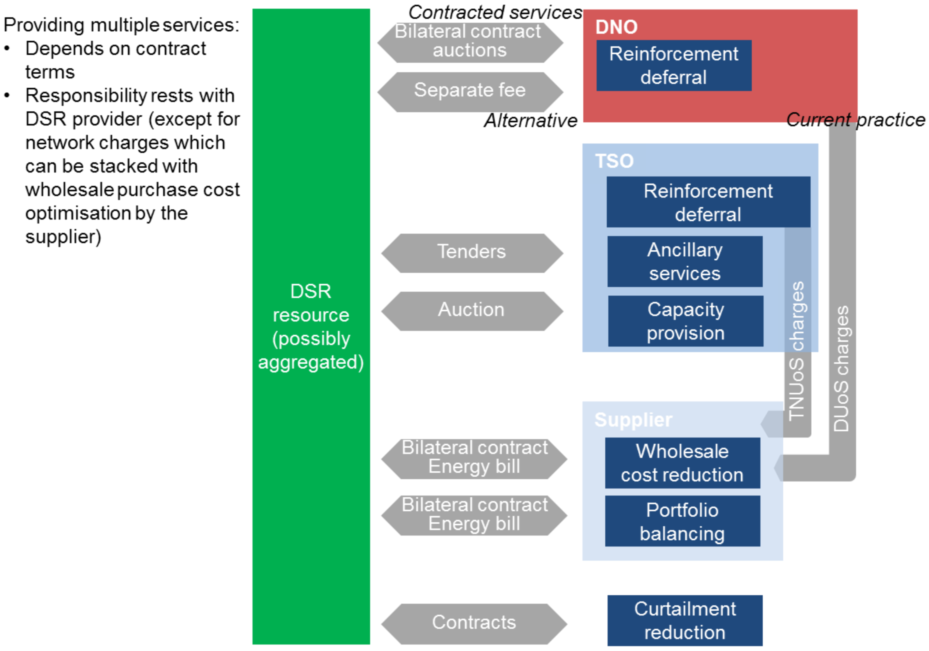

Figure 13 Schematic overview of tariff and bilateral contract framework

6.1.2 Rules based framework

One approach to capturing multiple value streams is with a coordinated industry rules based approach. This provides joint access of DSR resources by different parties, providing procedures for procurement and utilisation of DSR services from the same DSR provider, building on current regulatory arrangements. The framework needs to address which use cases are compatible for sharing and bilateral contractual conditions need to enable sharing between different stakeholders.

An example is the ENA shared services framework that is being developed. The focus of this framework is on how DNOs can maximise the DSR value chain within the price control periods for

RIIO-T1 and RIIO-ED1, with particular emphasis on the TSO and DNOs, and focussing on commercial and industrial DSR resources.

The ENA shared service concept paper provides a framework for DSR sharing between TSO and DNO with two distinct "pathways", based on two key elements:

- When notification of the DSR service requirement is declared.
- Which party receives the benefit from the DSR when utilised.

The alignment path captures the arrangements when a DSR action benefits only one party, or requires sole use. Procedures are defined that determine hierarchy of priority for accessing DSR resources. Priority access is given for usage of DSR to limit network peak loading, as deferral of reinforcements relies on guaranteed DSR capacity being available. In this pathway a DSR provider can potentially benefit by providing DSR services to different parties, except for when their needs are simultaneous.

The asset sharing path describes the case in which all parties can benefit from calling the DSR resource at the same time with no detriment to the other parties. In case different DSR uses are complementary, an asset sharing path is proposed. An example is the SO contracting DSR for availability to provide reserve services, while the Network Operator also has an option on the DSR resource for post fault management. Neither is using the resource continuously and the likelihood that both would want to call on the DSR resource simultaneously is low.

The relations between the various stakeholders in the rules based framework are depicted in Figure 14. Procurement of DSR resources by network operators, especially for on-demand I&C resources is coordinated through an industry agreed process. This framework could also be extended to include suppliers. The contractual and billing relations between providers and users of DSR are similar to those in the tariffs and bilateral contracts framework, but enable lower transaction costs and increased sharing of resources.

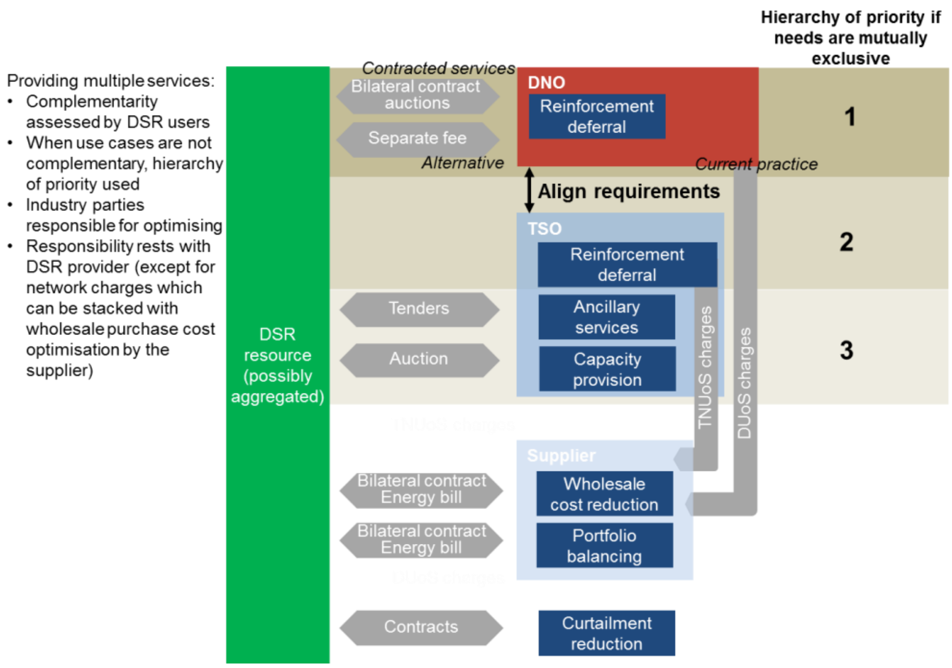

Figure 14 Schematic overview of rules based framework

6.1.3 Distribution System Operator (DSO)

In the DSO model the DNO has devolved responsibility for local balancing and grid stability management. It represents the biggest change in the role of the DNO from managing assets to delivering electricity grid services. The DSO operates a flexible network with the ability to control load flows, and optimises local DSR resources and other sources of flexibility for distribution network and wider system benefits. To this end the DSO would procure local system services, similar to the TSO at the national level. The current regulatory framework does not provide such a market based role for DNOs, and it would constitute significant changes.

The relations between the various stakeholders if the role of DNOs develops into that of a DSO are depicted in Figure 15. This system is defined by the additional system responsibilities for DSOs, and access to DSR resources for different stakeholders can still be arranged in various ways. This framework may become interesting with very high or clustered uptake of intermittent generation and low carbon load technologies, similar to the drivers for the development of the current active network management areas. The DSO will have the responsibility to carry out local balancing of demand and supply, and residual system balancing will be carried out by the TSO. DSOs will be responsible for a number of local functions which could be provided by DSR and are therefore in a stronger position to procure DSR and to manage these resources across their different use cases, notwithstanding the DSR use cases for other stakeholders.

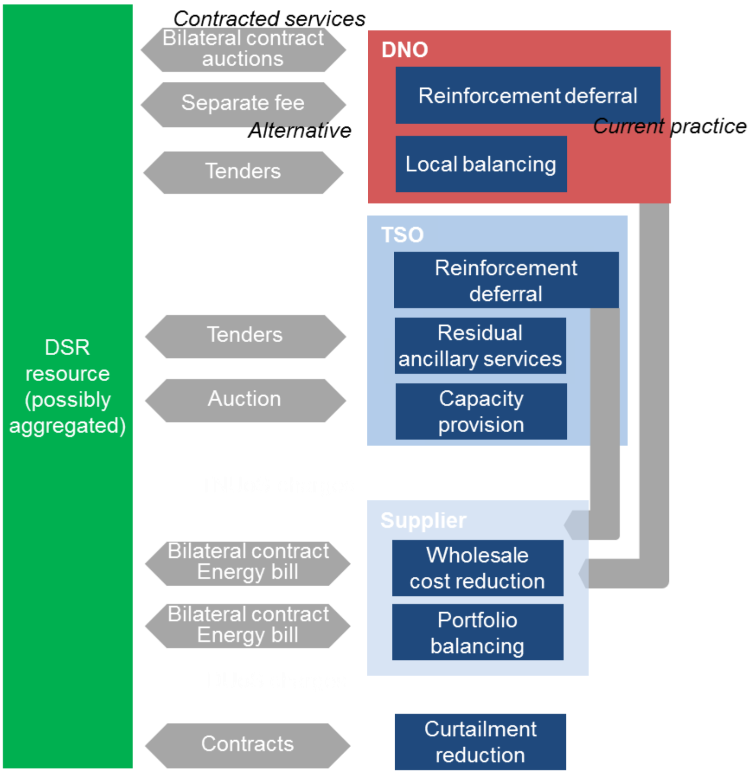

Figure 15 Schematic overview DSO

Customer-Led Network Revolution

6.1.4 Central flexibility market

In a central flexibility market, providers would bid DSR resources into a market platform encompassing flexibility products with various characteristics, e.g. location, capacity, duration, ramp rate, response rate. Users would procure DSR resources from the market platform. This model represents the most far reaching changes in the commercial arrangements between the various stakeholders. It would allow complex interactions between a large number of stakeholders, and potentially maximise the efficient use of DSR resources. The relations between the various stakeholders in the flexibility market are summarised in Figure 17.

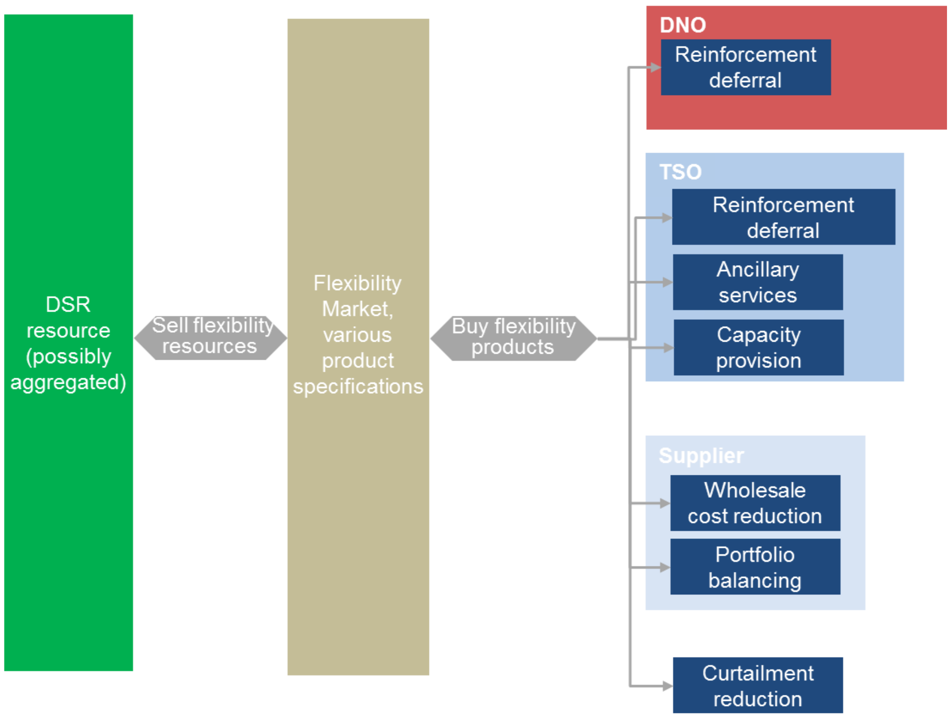

Figure 16 Schematic overview of a flexibility market

7 Barriers to the deployment of DSR and their potential solutions

Barriers are differentiated between the residential and SME sectors, I&C sector, and EES. Within each of the categories we address regulatory, commercial and economic barriers. The review of each barrier is based on an extensive literature review, and workshops and interviews with CLNR project industry experts. The main barriers in each sector are reviewed in the summaries and table below. The table distinguishes between barrier types (economic, commercial, regulatory), potential solutions, applicable sectors and parties best placed to resolve the barriers. The appendix provides a more comprehensive overview of the barriers identified in CLNR.

The barriers identified in the residential and SME sectors include regulatory barriers (which limit the ability of DNOs to provide residential customers with visibility of the DSR opportunities), the lack of sufficiently attractive commercial propositions and wider market issues such as conflicting needs and spill over effects amongst stakeholders.

In the I&C sector, the provision of some forms of DSR services is well established. The main challenge for DNOs, as evidenced in the recruitment process during CLNR trials ([11], [12]), seems to be the ability to recruit large flexible loads in sufficient numbers on specific areas of the network. Standardised contracts, better knowledge of connected customers (e.g. load characteristics, contact details) could improve the situation. Additional key issues for large scale adoption are the current inability for DSR providers to provide services to multiple parties, perceived risks to core business and services compared to the potential gains and lack of established and trusted frameworks for the procurement and provision of DSR services.

Electrical energy storage (EES) can provide similar functions for the electricity system as those provided by demand side response, and it also faces similar barriers. The EES trials in CLNR have focussed on the network management and technical aspects of storage rather than the commercial arrangements. The batteries in the trial were operated as distribution assets, for sole use by the DNO. There are several barriers for this commercial model. Especially exclusivity conditions of some ancillary services, and regulatory limitations for DNOs to participate in the market.

A number of alternative commercial models for the operation of grid connected EES could be deployed. Notably EES assets could be operated by merchant storage operators, providing services to various stakeholders. This limits the market exposure and commercial risk to the DNO. On the other hand it could also reduce the control a DNO has on the location, capacity and utilisation of EES assets.

Barrier type	Barrier description	Potential solutions	Applicable sectors	Party best placed to resolve
Economic/ commercial	Inability for customers to access whole value of their DSR resources (on-demand, dynamic and direct control DSR), limited ability to provide multiple services to different stakeholders	- Coordinated industry approach to develop multilateral contracts or sharing agreements. Market innovation and new business models to aggregate value. - Innovative business models developed using smart metering opportunities	Mainly I&C, EES, dynamic and direct controlled Residential & SME Residential & SME	Supplier, NOs, SOs, third parties Supplier, third parties
Economic/ regulatory	Lack of sharp price signals	- More volatile wholesale and balancing prices	I&C, EES, SME, residential	Regulator
Technical/ economic	Lack of smart appliances	- Attractive smart capability propositions for customers - Industry enablement of appliance smart functionality - Mandate smart capability of new suited appliances	Residential & SME	Supplier, third parties Supplier, NOs, SOs, third parties Government
Commercial/ technical	Risks to business operations and processes	- Propositions which target non critical business loads or processes, or critical business loads or processes in a low risk non-intrusive manner - Provide override functionality	SME and I&C SME	Suppliers, third parties Suppliers, NOs, SOs, third parties
Commercial	Large diversity of businesses with varying practices	- Identify generic appliances suited for DSR and better understand sub sector processes. Commercial approach using a "suite" of propositions for different customer types.	SME	Suppliers, third partied
Commercial	Energy management a low business priority	- In person site visits to review the options may support customers engaging with DSR opportunities	SME	Suppliers, third parties
Commercial	Acceptability of complex tariffs and customer protection	The evidence from CLNR suggests this barrier may not have a significant impact; that customers are comfortable with and engage with the various propositions that have been trialled	Residential	Regulator, supplier, NO
Commercial	Conflicting needs and negative spillover effects between stakeholders, and high transaction costs for bilateral contracts	- Coordinated industry approach to develop multilateral contracts or sharing agreements - Market innovation and new business models to aggregate value.	Mainly I&C, EES, and dynamic and direct control DSR	Supplier, NO, SO Supplier, third parties

Barrier type	Barrier description	Potential solutions	Applicable sectors	Party best placed to resolve
Commercial/ regulatory	Lower efficiency of DSR propositions without half hourly settlement	- Introduction of half hourly settlement, increased experience with adapted SSC settlement for DSR	Residential	Regulator
Commercial/ regulatory	Limited ability to develop residential charging and settlement propositions for dynamic or direct control	- Introduction of half hourly settlement - Adapted settlement process - Contractual arrangements outside of the settlement and charging arrangements	Residential	Regulator Elexon, supplier Supplier, third parties
Commercial/ regulatory	Lack of control over customer three rate DUoS uptake	- Currently being developed, but uptake dependent on supplier	Residential	Supplier, regulator
Commercial/ regulatory	Costs of network reinforcements resulting from the uptake of additional distributed low carbon technologies are socialised	Require new large and flexible electric loads to participate in DSR	Residential, SME	Regulator
Commercial/ regulatory	Uncertainty of long term availability of customers' DSR (mainly for I&C)	- Take up in connection agreement - Large portfolio of DSR providers	I&C I&C, residential, SME	Regulator Supplier, NO, SO, third parties
Commercial/ regulatory	Visibility of large new domestic connections	Ensure DNOs and suppliers receive information: - Enforce National terms of Connection - Through installers and equipment manufacturers	 Residential, SME Residential, SME	 Regulator Regulator, industry
Commercial/ regulatory	Transparency of DSR actions across stakeholders	- Coordinated industry approach to develop transparency	I&C, residential, SME	Regulator

8 Next steps to develop CLNR interventions to Business as Usual

In this section the key current barriers to the development of DSR and EES are reviewed, and the next steps identified for deploying the interventions that were trialled in CLNR as a business as usual option. These are therefore assessed within the context of the near term commercial frameworks, tariffs and bilateral contracts and the rules based approach. Full DSO or flexibility market frameworks would require significant changes to industry codes and roles.

8.1 Treatment of potential DSR savings in price control

Ofgems's final determinations on the RIIO-ED1 business plan expenditure assessment [34] already include expected savings across all the DNOs of £ 963m[37] from smart grid solutions compared to Business As Usual. DSR contributes to these savings in cases where its use can defer or avoid network reinforcement at a lower overall net present value cost (DSR payments plus operational costs) than the deferred or avoided reinforcement. EES is unlikely to feature in solutions in the RIIO-ED1 period.

However, if DSR solutions can be realised at lower costs than the assumptions already embedded in the business plan, this provides further savings which are shared between customers and the DNO under the Information Quality Incentive (IQI). The capitalised value of this saving (typically 70%), is shared by customers and the DNO. The distribution is determined by the DNOs IQI, which for Northern Powergrid is currently 54:46[38] (54% is distributed to customers, while Northern Powergrid receives 46%). Customers receive this benefit in the form of a socialised reduction of the Distribution Use of System (DUoS) tariffs with a lag of two years. The contribution in the next price control period is a socialised reduction in DUoS tariffs, due to reduced investment costs.

8.2 Sector specific next steps

8.2.1 Residential and SME sectors

The CLNR trials have found that voluntary adoption of static DSR through suppliers is a feasible route to engage residential customers. DNOs are however unlikely to proactively deploy such propositions in a geographic area, because of the need to engage with a large number of customers without a direct relation with DNOs, but their adoption will release some headroom on DNO networks.

Uptake is therefore more likely to be supplier-led, requiring a clear incentive for suppliers to offer these tariffs, which is currently limited. Combined with other preconditions such as smart metering and more effective settlement on adapted Standard Settlement Configurations (SSC), means these are more likely to be commercially deployed at scale towards the end of RIIO-ED1 and beyond.

[37] Table 11.1, total smart saving
[38] In DPCR5

Dynamic or direct control DSR could provide further assurances to DNOs that peak demand is in effect reduced at periods of maximum load, and could enable suppliers to deploy DSR more widely.

8.2.2 I&C sector

The CLNR project has successfully engaged I&C DSR providers on the basis of commercial contracts, developed by the project. These interventions can potentially be deployed by the DNO within RIIO-ED1. However better means of accessing the market need to be developed, together with a means for DSR providers to provide responses to different parties.

Many of the I&C customers that participated in the CLNR trial had prior experience of providing STOR, and were interested in trialling the provision of new services. This indicates an active interest from I&C customers to provide DSR to DNOs. Moreover the trials were carried out on the basis of commercial contracts which were developed within CLNR. It seems feasible to deploy this form of DSR in RIIO-ED1, although both the supply to DNOs and the benefit to DSR providers could benefit significantly from increased industry coordination to enable the effective provision of multiple services from DSR resources.

Procurement of on-demand DSR resources in an auction seems a suitable way to determine contract prices. The price of DSR for this use case, based on the counterfactual reinforcement costs and required utilisation and availability can vary significantly for different locations on the network, which makes it difficult to establish suitable prices. In an auction format providers of DSR can assess required price points, taking into account potential other available value streams. These DSR resource prices can then be compared by the network operator against counterfactual reinforcement options.

8.3 DSR categories next steps

8.3.1 Static DSR

Few direct barriers exist for SToU tariffs, as implemented in CLNR, to be deployed as a business as usual proposition. DNOs are however unlikely to proactively deploy such propositions, and there are currently limited incentives for suppliers. Moreover, industry code changes and programs for key preconditions that are required to deploy these tariffs as Business as Usual, are still being developed, including smart metering, three rate DuOS charges for residential customers and adapted profiling in settlement. CLNR trial experiences also showed there are areas of attention for implementation. This means these tariffs are more likely to be commercially deployed at scale towards the end of ED1.

CLNR has been successful in commercially engaging customers in a static ToU tariff and in implementing the processes for these tariffs. This suggests that voluntary adoption could be an effective route and mandating such tariffs is not likely to be necessary. CLNR was also successful in deploying these tariffs through suppliers, avoiding the need to change billing arrangements and DNO customer engagement.

In practice it has been possible for suppliers to offer and settle smart meter customers against static Time of Use Tariffs, within profile class 1. This requires a supplier to create a new Standard Settlement Configuration (SSC) with Elexon for that group of customers. This has been implemented by British Gas for this trial. An adapted SSC profile was created for the ToU tariff customers, which was further calibrated as more consumption data became available during the trial.

British Gas did however experience that the demand allocated in the peak period in the settlement process was higher than metered data and the profile class 1 demand. The higher allocated peak demand resulted in lower savings compared to the expectation in the design of the Time of Use Tariff. The use of SSC illustrated the complexity of the non-half hourly (NHH) settlement arrangements and challenges to produce accurate allocation of demand. Industry code changes to enable this as business as usual are being developed, as further discussed below.

Three-rate DUoS charging for half hourly (HH) metered customers in profile classes 1-4 are expected to be available for use from November 2015. These tariffs will however be voluntary and DNOs are also dependent on suppliers to offer these to customers, as suppliers are not obligated to change the meter registration for existing customers.

The changes to DCUSA are set out in proposal DCP179 which was approved by Ofgem in October 2014. This proposal makes changes to the HH and non-Half Hourly (NHH) tariffs for LV customers. The new HH tariffs are only made up of unit rates and fixed charges, which is consistent with current NHH tariffs. DCP179 also foresees aggregated billing for HH LV customers without current transformers (non-CT). DCP179 also requires the introduction of new measurement classes for settlement, which are developed through proposal P300 for the BSC (also approved by Ofgem in October 2014).

A further move towards full half hourly settlement of residential customers could provide additional efficiency through more accurate settlement of customers and increased price reflectiveness. Half hourly settlement for profile classes 1-4 is currently being reviewed by OFGEM [41].

Although the CLNR SToU trials showed an average 2.1%-10.3% reduction in peak period peak demand, the demand at the absolute peak time wasn't necessarily reduced. This entails a risk especially for the DNO. The restricted hours trials on the other hand showed a very high reliability of demand reduction by customers. This indicates that some form of load control or appliance automation in combination with a SToU tariff could provide a higher reliability of response at moments of need for the DNO.

In this model DNOs rely on suppliers to deploy SToU tariffs. This is a key commercial risk for DNOs, as they do not have direct control on securing sufficient capacity. Similarly previous SToU tariff customers could adopt other tariff structures when they change suppliers.

A further key aspect for SToU tariffs is the fact that the cost drivers for different stakeholders need to be aligned to capture their value in the tariff and send a strong price signal to the customer. The local and national network peak demand periods and peak price periods are now relatively well aligned, but this is expected to increasingly diverge in the future, especially beyond RIIO-ED1.

The adoption of a rules based sharing framework does not seem to provide additional value beyond what can be captured in the tariff and bilateral contract framework.

8.3.2 Dynamic DSR

The CLNR trials indicate that customers are willing to change demand in response to a dynamic signal. An automated response by appliances seems to provide larger potential for demand change. The dynamic response trialled in CLNR, in home balancing of PV generation, is focussed on

reducing the impact of distributed generation export on the network, and does not require specific changes to industry codes to be taken up, although that could support capturing additional benefits.

The main purpose of the in premise balancing is reducing the electricity bill of customers and in the future reducing local network stress due to high aggregate export of distributed electricity. There could be instances however in which the DNO would benefit from increased local generation, when demand is high. The CLNR trial does not however have a mechanism for the DNO to signal that need to the customer. This could either be achieved through a form of direct control or dynamic pricing. The latter requires half hourly settlement to be able to implement.

8.3.3 On-demand DSR

The residential CLNR trials with direct controlled washing machines and heat pumps showed that these can have a statistically significant contribution on peak demand reduction of these applications.

This has even been realised despite the inevitable technical issues associated with the first UK application of these technologies. The trials also showed that having an override function on direct load controlled appliances did not materially impact the reliability of response, i.e. it wasn't used often. This is encouraging, as the lack of control over one's own appliances is often seen as a barrier for customers to adopt direct load control interventions. These results show that when an override is provided this doesn't necessarily impact the value for the DNO significantly.

In CLNR the provision of on-demand DSR from I&C customers through aggregators and directly with the DNO has been trialled successfully. This is a feasible way to unlock DSR resources in the near term, which does not require changes to industry codes. However DSR resources could potentially be utilised more effectively with a coordinated industry approach.

While trials only considered the use of DSR for the DNO, these DSR resources could provide services to multiple stakeholders. The cost drivers for these use cases are however different, have varying value and are not always compatible. This means that access to the DSR resource and priority when multiple stakeholders are vying for the same resource, are key elements. In the current situation the scheduling of DSR resources for different services can be carried out by aggregators or other third parties. The contractual limitations for some services, and required guarantees for delivery however mean that these resources could be utilised more efficiently. A near term solution for this is a rules based framework, such as the ENA shared service framework.

A key element in determining the value of individual DSR interventions to the DNO is the extent to which these responses contribute to overall peak demand reduction. This depends, for all DSR categories, on the reliability of response. Changes are under approval for Engineering Technical Report (ETR) 130, underlying security standard Engineering Recommendation (ER) P2/6, to treat DSR similar to embedded generation. ETR130 defines the contribution of embedded generation (and DSR) to network peak demand reduction as capacity times confidence factor (F factor). These factors can be defined by individual DNOs. ETR130 furthermore includes technical regulations to limit the reliance of network design on generation (and hence DSR).

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APPENDIX - Barriers to the deployment of DSR and their potential solutions

Barriers are differentiated between the residential and SME sectors, I&C sector, and EES. In each, barriers are classified according to their impact on three categories:

- DSR providers barriers for DSR engagement.
- DNO-specific barriers.
- Wider market barriers.

Within each of the categories we address regulatory, commercial and economic barriers. The review of each barrier is based on an extensive literature review, and workshops and interviews with CLNR project industry experts [39].

1. Residential and SME market

The barriers identified in the residential and SME sectors include regulatory barriers (which limit the ability of DNOs to provide residential customers with visibility of the DSR opportunities), the lack of sufficiently attractive commercial propositions and wider market issues such as conflicting needs and spill over effects amongst stakeholders[40].

1.1. DSR provider barriers

1.1.1. ToU - inability for customers to access whole value of their DSR resources

Type of barrier: commercial / economic

CLNR has shown that customers are able to deliver multiple benefits from the accessible use cases in a ToU tariff. Benefits of network savings can in the near future be passed on to customers through three rate DUoS charges. Current arrangements require the supplier to offer these interventions commercially. Current benefits to suppliers and customer savings are however still limited, moreover how DUoS savings are passed on depends on the structure of the supplier commercial proposition to customers.

Solutions: underlying commercial drivers, especially for suppliers, may become more attractive with more volatile wholesale and balancing prices, and higher transmission & distribution investment requirements. Moreover, other innovative business models may be developed using smart metering opportunities, which increase the engagement of suppliers with new propositions to customers.

[39] Workshops were attended by British Gas and Northern Powergrid experts on asset management, commercial and regulatory areas, as well as by engineering and social science representatives of Durham University.

[40] In the CLNR trial, the main challenges for the recruitment process were technical (e.g. lack of interoperability of existing smart meters and new metering components), the difficult identification of suitable existing customers with low carbon technologies installed or willing to pay the installation remaining costs after subsidies and the acceptance of the complex process to join the trial by customers in general, and in particular, the acceptance of innovative propositions (i.e. restricted hours or direct control interventions). The CLNR trial were early adopters of smart meters, these challenges are expected to be addressed as part of the wider smart meter roll out.

1.1.2. On-demand DSR - inability for customers to access whole value of their DSR resources

Type of barrier: commercial / economic

Direct load control type propositions, could also provide additional use cases (such as ancillary services). Such propositions are however not currently offered commercially, and customers are not able to capture the full potential value of DSR resources from the provision of multiple services across the value chain. For this to be realised, business cases collating the value from several stakeholders need to be developed and accessible. A key example is the contractual conditions of some ancillary services that limit the ability to commit resources for additional uses. The impact of this barrier is that customers might not be able to access incentives high enough for them to provide DSR services or resulting in a reduced uptake of DSR.

Solutions: coordinated industry approach to develop multilateral contracts or sharing agreements, or market innovation and new business models to aggregate value.

1.1.3. Lack of smart appliances

Type of barrier: commercial / technical

On demand and dynamic DSR propositions can be supported by smart appliances. Although additional costs to enable smart control of appliances are relatively limited, without uptake of these propositions, there is no incentive for manufacturers to do this.

Solutions: ensure smart capability is an attractive proposition for customers, support industry enablement of appliance smart functionality, or alternatively mandate smart capability of new suited appliances.

1.1.4. SME risks to business operations

Type of barrier: commercial

The perceived impact of Demand Side Response, especially forms of direct control, on SME business operations is found to be critical. This is discussed in more detail in section 5.1.

Solutions: Develop propositions which target non critical business loads, or critical business loads in a low risk non-intrusive manner. Provide override functionality, experience from CLNR shows that this provides assurance to customers but that over-ride is used limitedly.

1.1.5. SME heterogeneity and customer engagement

Type of barrier: commercial

The SME sector is very heterogeneous, with a large diversity of limited scale businesses with varying practices. The large variety limits the opportunity to apply standardised solutions, while smaller scale limits the commercial attractiveness to offer bespoke solutions. The experience during the CLNR trials showed [20] that despite a large willingness of SMEs to explore opportunities for DSR in a majority of cases DSR offers were regarded as incompatible with the business due to the potential impact on the service to their customers. Standardised DSR requirements were offered to customers, which may have contributed to the lack of success in the recruitment of a very heterogeneous group requiring bespoke propositions with solutions. This is discussed in more detail in section 5.1.

Across all the sectors, certain loads are perceived as inflexible, and hence not available as a DSR resource. It seems that SMEs perceive a larger part of their loads as inflexible, compared to domestic customers. In part this can be due to the nature of their business, but the social science research conducted in CLNR also indicates that certain fixed practices are an important contributor to this inflexibility.

Solutions: identify generic processes and appliances that are suited for DSR, better understand sub sector processes. Commercial approach using a "suite" of propositions for different customer types.

1.1.6. Low priority of energy management

Type of barrier: commercial

Energy is often a secondary issue for SMEs and commercial customers [7], as it is not their core business and, quite often, not their main cost. Although the SME survey showed that energy reduction is perceived as an important issue and that most SMEs believe they need to reduce their energy use, there is very little real involvement towards energy reduction[41]. The trials found there is often a lack of DSR awareness, or it is considered a lower priority than energy efficiency measures. The customer engagement furthermore found there is often no person responsible for energy management or, if there is, they are difficult to identify / contact. Particular cases include multi-tenanted buildings, where the landlord is responsible for energy[42], or franchises, where energy is centrally managed.

Solutions: CLNR engagement showed that in person site visits to review the options supported customers engaging with DSR opportunities.

1.2. DNO-specific barriers

This section presents the barriers that specifically apply to DNOs, including regulatory barriers, lack of DNO's visibility of new connected loads that could provide DSR and lack of a DNO-customer relationship.

[41] Most SMEs never conducted an energy audit, do not have a Display Energy Certificate, do not have personnel involved in energy management or have never sought to get support/advice (e.g. through Carbon Trust) to improve their environmental sustainability
[42] Element Energy interviews identified that landlords of multi-tenanted buildings will never consider the implementation of measures that could impact their tenants without consulting them first

1.2.1. Distribution Connection and Use of System Agreement (DCUSA[43])

Type of barrier: regulatory

A comprehensive review of barriers related to the common distribution charging methodology (CDCM) and common connection charging methodology (CCCM) is provided in CLNR's first report on commercial arrangements [7], and the Smart Grid Forum WS6 report on barriers [8]. Subsequently, these barriers will be described briefly and the focus will be on insights from the CLNR trials, workshops and interviews.

Common distribution charging methodology (CDCM) for LV and HV non-half hourly metered customers

Current DUoS charges for non-half hourly customers do not allow DNOs to signal DSR benefits to suppliers[44], resulting in an inability to incentivise non-half hourly customers. Three rate DUoS charges are currently being developed for profile classes 1-4, through DCP179 'Amending the CDCM Tariff Structure') which was approved by Ofgem in October 2014 with an implementation date of April 2015 and BSC proposal P300 for the BSC, with an implementation date in November 2015. These changes are focussed on SToU tariffs.

DNOs can set appropriate rate structures for their network areas, similar to current practices. DNOs are however dependent on suppliers to adopt these new tariffs and pass them on to customers, as they are not obligated to change the meter registration for existing customers.

Solutions: currently being developed, as per above. Introduction of half-hourly settlement could enable further efficiencies in engaging and settling DSR.

Common connection charging methodology (CCCM)

Under RIIO-ED1[45], costs of network reinforcements resulting from the uptake of additional distributed low carbon technologies are socialised. This diminishes the driver for customers that connect new distributed loads to enter into bilateral DSR arrangements, and limits the ability of DNOs to pass on cost-reflective incentives to other customers on the same circuit that could provide a DSR resource.

If other customers can provide DSR to defer reinforcements for the connection of new large loads, the DNO is unable to pass on the full cost reflective benefit of this to the DSR provider, due to socialisation of part of these savings.

Solution: An option to address this is to require new large and flexible electric loads to participate in DSR, as is for instance implemented in Spain for electric vehicles.

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[43] DCUSA governs connections and use of system in the distribution network through the Common Distribution Charging Methodology (CDCM), Extra High Voltage Distribution Charging Methodology (EDCM) and the Common Connection Charging Methodology (CCCM)
[44] While DUoS for HH customers include different unit rates and capacity charges, there is a unique unit charge and no capacity charges for domestic customers
[45] In March 2013, Ofgem set its Strategy Decision for RIIO ED1, including this socialisation of costs

1.2.2. Distribution Licence conditions (security of supply standard)

Type of barrier: regulatory

There are two main barriers related to the Distribution Licence conditions[46]:

- the security of supply standards.
- DNO activity revenue caps (specific for EES, see section 3).

ER P2/6 defines the required levels of security of supply in terms of the time to restore supplies to customers affected by any interruption. The Security of Supply Standard (ER P2/6) was until recently recognised as a potential barrier to DNO engagement with DSR [8], with implications for the potential of DSR as an alternative to network reinforcement.

Solution: A recent change proposal is under approval for ETR130, underlying ER P2/6, to treat DSR in a similar way to embedded generation in terms of provision of security of supply[47]. Critically, DNOs are required to define reliability standards for DSR solutions individually. The revenue cap does not likely limit the development of EES projects in the near future. This is not a material barrier, as consent can be sought from Ofgem to relax this limit [25]

1.2.3. Uncertainty of long term availability of customers' DSR

Type of barrier: commercial

DNOs require long-term certainty in order to defer network reinforcement costs. This can conflict with shorter term commitment by customers, and potential withdrawal from DSR arrangements. Change of supplier supporting non-ToU tariffs might be a cause for this. Cheaper non-ToU tariffs could be another[48]. This poses a risk for the adoption of DSR to DNOs, as it may increase overall costs if reinforcements are required at a later time due to a reduction of available DSR capacity [10]. This is especially pertinent where DSR is used as a lower cost alternative for the connection of new loads or generation. In a case where a DSR provider withdraws and no new DSR resource can be found, this presents an issue on how or whether the potential higher cost reinforcements should be levied on the original connectee. Although this risk is also faced for residential and SME DSR, it is most pertinent for DSR provision by I&C customers, as these provide individually larger capacities.

Solutions: DNOs would attain additional certainty by using DSR from a large portfolio of clients. Even if reinforcements are required at a later stage this can represent a deferral and option value to the DNO, as further discussed in section 4.1.1.

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[46] Licence conditions apply to certain 5 types of electricity licencees: distributors, generators, transmission operators, interconnectors and suppliers, and managed by Ofgem

[47] Accommodating DSR in ER P2/6 – Change proposal part of capacity to customer (C2C) project (Electricity Network West, Feb 2014)

[48] In the EV survey showed that 60% of the interviewees stated to be interested in changed supplier to take advantage of cheaper or greener electricity tariffs, as opposed to 25% not interested.

1.2.4. DNO visibility of large new domestic connections

Type of barrier: commercial

Although there is a requirement on customers to inform the DNO of disruptive loads under the National terms of Connection, there is no formal process for this and there is no obligation to notify the DNO about the connection of individual large domestic loads such as heat pumps and electric vehicles, even though these can contribute to network constraints.[49] [8]. This lack of visibility of where loads are connected, limits the DNOs ability to plan network reinforcements or DSR accordingly. Additionally, this also reduces the ability of DNOs to identify these customers, some of which have significant potential to provide DSR services.

Solutions: Ensure that DNOs and suppliers receive information. This may be done by enforcing the current National terms of Connection, which may be challenging, or possibly through installers and equipment manufacturers, which would require new regulations.

1.2.5. Lack of DNO -relationship with domestic customers

Type of barrier: commercial

DNOs have no established direct relationship with domestic customers. Within the supplier hub model DNOs do not currently have access to the same data as suppliers and have no billing relationship with the customer. Within the current Smart Energy Code DNOs will also not have access through the DCC to type A communication, which is required for instance to upload tariff data. This is the responsibility of the supplier, and would moreover require a billing relation between the DNO and the customer.

The supplier hub model does provide transparency to customers, through a single point of contact and supplier competition. The supplier hub model moreover does not preclude other parties, including DNOs, from interacting with customers and developing innovative services. It would, however, have cost implications for the DNO, such as setting up separate administrative systems and appropriate billing / payment systems. This barrier may be reduced through economies of scale by engaging with customers via intermediaries, such as suppliers or aggregators.

A further issue for DNOs is that within the supplier hub model, DNOs may need to deal with a large number of suppliers within a specific geographic area to engage sufficient customers in DSR. Alternatively, for dynamic DSR types, DNOs could contract commercially with other third parties, or suppliers.

[49] There is only a mechanism for notification of multiple Small Scale Embedded Generators connection (ER G83/1-1)

1.3. Wider market barriers

1.3.1. No charging or settlement arrangements are currently established for Dynamic and on-demand DSR

The CDCM and settlement for residential customers do not support dynamic or on-demand DSR provision. Dynamic response from residential customers could be enabled either through the settlement process or outside of that based on bilateral or multilateral contracts. The provision of dynamic response through the settlement process requires further adaptations of current arrangements. Dynamic Response can be enabled by introducing dynamic tariffs and half hourly settlement, or in a more limited way through the adoption of static clock switched profile types, similar to Economy7 or 10. Elexon is currently carrying out a consultation on these two options. Additionally half-hourly settlement enables more accurate settlement and supports more time of use reflective price signals. Half-hourly settlement for residential customers is currently being reviewed by Ofgem.

Dynamic response based on bilateral or multilateral contracts is carried out in various trials. When this would be adopted at larger scale, this could impact the imbalance position of suppliers and settlement accuracy without additional arrangements.

Solutions: adapted settlement process, half-hourly settlement or contractual arrangements outside of the settlement and charging arrangements

1.3.2. Acceptability of complex tariffs and customer protection

Type of barrier: commercial

There is a trade-off between the level of complexity of supply and distributor network operator tariffs offered to customers, the level of complexity that customers are willing to accept and Ofgem's commitment to transparency[50]. As a result of this inevitable requirement for compromise, tariffs acceptable to both Ofgem and customers may not deliver the full technically feasible potential benefit to DNOs (or to suppliers).

Solutions: The evidence from CLNR suggests this barrier may not have a significant impact; customers are comfortable with and engage with the various propositions that have been trialled, including SToU and direct control types of DSR.

[50] Ofgem launched the Retail Market Review on 2010, under which the Simpler, Clearer, Fairer energy supply reforms were released (requiring cleared bills from 31st March 2014)

1.3.3. Lack of sharp energy price signals

Type of barrier: commercial / economic

The principle of cost reflectivity is usually seen as contributing to the efficient working of electricity and balancing markets and other system services. Cost reflectivity in general also supports the uptake of DSR where this is an efficient solution. However, this also implies the potential for greater price volatility to customers, and the impact of sharper price signals on customers in fuel poverty is an important consideration in the design of commercial DSR arrangements and the protections that may be required, especially where some customer groups would have limited ability to respond to signals, as discussed in section 5.1.1.

One area where price signals for DSR are not fully cost reflective is in wholesale and balancing markets. EBSCR changes are already moving towards more marginal cash-out prices (i.e. more representative of the most expensive balancing actions that need to be taken). Another area are the DUoS charges, which are not location specific within DNO areas, and not fully reflective of time of use.

1.3.4. Conflicting interests between stakeholders

Type of barrier: commercial

The fact that the cost drivers of DSR for DNOs may not always be aligned with those of other industry stakeholders is a key issue in the development of DSR, as it creates competing interests for the use of DSR resources. As discussed in section 5.2, the cost drivers for DNOs, TSOs and suppliers are currently often aligned. These may however diverge more strongly with increasing uptake of low carbon technologies and intermittent generation, which can reduce the correlation between local peak demand, system peak demand and peak price periods [5] [15]. Even if cost drivers are aligned DSR actions by one stakeholder can have negative spillover effects for other stakeholders if they do not have advance visibility of these actions. Suppliers for instance could experience small deviations in their imbalance from DNO instructed DSR actions post gate-closure. The impact of DNO use of DSR for post-fault management on supplier balancing position was identified to be low for the short/medium term (low levels of DSR uptake), increasing as DSR becomes business as usual.

Solution: coordinated industry approach to develop multilateral contracts or sharing agreements, or market innovation and new business models to aggregate value.

1.3.5. High transaction costs of bilateral contracts

Type of barrier: commercial

At the moment, DSR contracts are arranged bilaterally (e.g. STOR contracts between TSO and DSR providers), with the subsequent high transaction costs associated (including information requirements for DSR providers), as the parties cannot benefit from sharing the fixed costs of setting up a contract.

Solutions: industry coordinated development of standardised contracting approaches. The participation of third parties, such as aggregators or suppliers, acting as the link between DNOs and DSR providers, could partly avoid the impacts of the high transaction costs associated with bilateral contracts.

1.3.6. Validation and verification of DSR response

Type of barrier: commercial

Although validation and verification of DSR delivery is not a barrier itself, it needs to be included as part of any commercial arrangement and included in the overall costs.

Solutions: Validation and verification techniques, tools and standard procedures need to be developed, trialled and validated.

1.3.7. Transparency of DSR actions across stakeholders

Type of barrier: commercial

As discussed in the barrier of *conflicting interests between stakeholders*, DSR actions can have both positive and negative impacts among stakeholders. Consequently, visibility and transparency of contracted DSR resources and DSR actions are critical to develop efficient use, and to provide certainty to new market entrants.

For example, for a supplier to be able to adjust their position, they need to know ahead of time when a DNO will utilise a DSR resource. This will not always be possible (e.g. when DSR is used in a post-fault management event), but often will be (e.g. day-in day-out DSR use to defer network reinforcement or for a fault that occurs several hours before the arrival of the evening peak). Suppliers would typically still be able to manage their position if they are notified of a DSR action during the 4pm-8pm peak by midday.

Solutions: Even if individual DSR actions are not communicated, suppliers could benefit from being aware of volumes of DSR contracted and the services they're contracted for, for different customer groups. This could give them a probabilistic understanding of the aggregate impact on portfolio level.

1.3.8. Large scale uptake of DSR is required for the development of commercial products by suppliers

Type of barrier: commercial

A high volume of customers is needed for new supplier products to offset overhead and marketing costs, typically in the range of 50-100k[51] customers.

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[51] Indicative range advised by British Gas experts.

1.3.9. Currently limited incentives for suppliers to participate in the DSR market

Type of barrier: commercial

Consultations with suppliers have indicated that there are no real barriers to the development of DSR propositions. However, suppliers feel little urgency to develop DSR propositions, due to limited incentives, the timescales for the roll out of smart metering, complexity of DSR propositions, uncertainty on future developments for DSR and the availability of low cost established alternatives. New entrants and suppliers without flexible generation may be more likely to develop initial DSR propositions[52].

2. I&C markets

The provision of some forms of DSR services is well established for I&C customers. The main challenge, as evidenced in the recruitment process during CLNR trials ([11], [12]), seems to be the ability to recruit large flexible loads in sufficient numbers on specific areas of the network. Standardised contracts, better knowledge of connected customers (e.g. load characteristics, contact details) could improve the situation. Additional key issues for large scale adoption are the current inability for DSR providers to provide services to multiple parties, perceived risks to core business and services compared to the potential gains and lack of established and trusted frameworks for the procurement and provision of DSR services.

2.1. DSR provider barriers

2.1.1. Recruitment barriers for DSR engagement

Type of barrier: commercial

The I&C engagement research[53] showed that while there are fewer barriers to I&C engagement with DSR, it is challenging to find sufficient I&C DSR resources within specific network areas and, again due to potential impacts on business operations, response via load turn down is difficult to achieve, with most I&C customers utilising their standby generators to provide the DSR service. In the trials, lead times from the initial customer approach to the finalisation of the DSR contract were also long, from 12-24 months.

Solutions: engage customers through aggregators and possibly suppliers, with established connections and resources. Develop standardised contracts and coordinated DSR sharing framework.

[52] In the workshops the fact that DSR is not considered for subsidies was raised. It was argued that while the uptake of renewables counts with incentives (FiT, ROC, RHI) and there are incentives backing DSR measures

[53] *CLNR - L014 Initial Report on I&C DSR (Northern Powergrid, Apr 2013, Stuart Brown)*

2.1.2. Negative perception issues

Type of barrier: commercial

Business continuity is a priority for I&C businesses, and hence, any risk to their operations and level of service is critical. Businesses will not consider the uptake of measures that could significantly impact their level of services.

Solutions: Develop propositions which target non critical business processes and loads, or critical business processes and loads in a low risk non-intrusive manner, ensuring propositions have no impact on the quality of service and operation.

2.1.3. Insufficient incentives

Type of barrier: commercial

The commercial incentives for a customer to provide DSR to only the DNO may not be sufficient for customers to offset perceived risks[54]. Customers may not be fully able to access the full value from the DSR services they provide. Especially for SMEs, the lack of sufficiently attractive propositions was identified in the trials as a key barrier to DSR uptake.

Solutions: enable the provision of DSR to multiple stakeholders to enhance the income potential.

2.2. DNO-specific barriers

2.2.1. Exclusivity of ancillary services contracts for I&C customers

Type of barrier: commercial

A key barrier to DNO-led DSR propositions in the I&C sector are the contractual conditions of some ancillary services that limit the ability to commit resources for additional uses [15] i.e. a provider of STOR services cannot provide services to a DNO without dropping out of STOR.

Solutions: develop industry coordinated rules based frameworks such as the ENA shared services work.

2.2.2. Uncertainty of long term availability of customers' DSR

Type of barrier: commercial

DNOs require long-term certainty in order to defer network reinforcement costs. This can conflict with shorter term commitment by customers, and potential withdrawal from DSR arrangements.

[54] In particular, upfront costs for DSR assets could be a barrier in some particular cases. However, it was not recognised to be a key barrier, as similarly to other low carbon technology and energy efficiency measures, commercial measures are likely to be developed in which customers invest themselves, alongside models where customers do not pay the upfront costs (e.g. ESCO models)

This poses a risk for the adoption of DSR to DNOs, as it may increase overall costs if reinforcements are required at a later time due to a reduction of available DSR capacity [10]. This is especially pertinent where DSR is used as a lower cost alternative for the connection of new loads or generation. In a case where a DSR provider withdraws and no new DSR resource can be found, this presents an issue on how or whether the potential higher cost reinforcements should be levied on the original connectee.

Solutions: This could be taken up in the original connection agreement, which would transfer this risk to the connectee. Alternatively DNOs would attain additional certainty by using DSR from a large portfolio of clients. Even if reinforcements are required at a later stage this can represent a deferral and option value to the DNO, as further discussed in section 4.1.1.

2.2.3. Barriers in common with the residential sector

Several of the barriers that hamper DNO ability to engage with DSR effectively in the residential sector are also relevant to SME and I&C sectors:

- **Distribution Connection and Use of System Agreement (DCUSA): CDCM** - DUoS charges for larger users in profile class 5-8, and HH metered customers connected to EHV do include time of use charges. E specially pricing in the EDCM is very specific. There is still significant room for flexibility on the side of suppliers in how they pass on DUoS costs to their customers as currently only about 5% of half-hourly metered customers are on multi-rate tariffs.
- **Security of Supply** – this barrier is reviewed in the residential DSR section; a recent change proposal is under approval for ETR130, underlying ER P2/6, to treat DSR similar to embedded generation in terms of provision of security of supply. Critically, DNOs are required to define reliability standards for DSR solutions individually.
- **Lack of DNO-customer relationship** – this is only a barrier for residential and SME customers, as I&C customers, have Connection Agreements with the DNOs, from which DSR arrangements could arise. Relationships between DNOs and I&C customers are currently being validated in several trials across the UK[55].

2.3. Wider market barriers

These barriers were mainly presented in the previous section on residential barriers. Here, the aspects that are specific to the I&C market will be presented.

- **High transaction costs of bilateral contracts** – near term I&C DSR services are likely to be contracted either bilaterally or through auctions. In the case of auctions, the high costs of bilateral contracts could be mitigated
- **Validation and verification of DSR response** – large scale deployment of DSR requires efficient processes for monitoring and settling of DSR delivery. In the CLNR winter 2012 I&C

[55] Examples of these projects are: FALCON (WPD), Low Carbon London (UKPN), Thames Valley Vision (SSE)

DSR trials56 this was carried out manually. The need to develop a more efficient process was identified as a requirement for larger scale use of DSR.

- **Conflicting interests of DSR stakeholders** – the underlying drivers for DSR use by different stakeholders are not necessarily aligned, and their use cases may be mutually exclusive or reduce individual value.
- **Transparency of DSR actions among stakeholders** – DSR actions taken by one party have the potential to impact other parties (adversely or positively), for instance a DSR instruction for network peak reduction by a DNO to an I&C customer can impact the imbalance position of a supplier. Especially with larger DSR volumes this can become an issue, requiring transparency of DSR actions or contracts. In the CLNR I&C trials the supplier of those customers was not involved, and not aware of their DSR actions, at this scale that wasn't seen as a significant commercial risk.

3. Electrical Energy Storage

Electrical energy storage (EES) can provide similar functions for the electricity system as those provided by demand side response, and it also faces similar barriers. The EES trials in CLNR have focussed on the network management and technical aspects of storage rather than the commercial arrangements. The batteries in the trial were operated as distribution assets, for sole use by the DNO. There are several barriers for this commercial model. Especially exclusivity conditions of some ancillary services, and regulatory limitations for DNOs to participate in the market.

A number of alternative commercial models for the operation of grid connected EES could be deployed. Notably EES assets could be operated by merchant storage operators, providing services to various stakeholders. This limits the market exposure and commercial risk to the DNO. On the other hand it could also reduce the control a DNO has on the location, capacity and utilisation of EES assets. This section summarises a few of the key generic, merchant and DNO operated EES barriers.

3.1. General EES barriers

- There are challenges in capturing multiple revenue streams [22], as is the case for DSR:
  - Contractual conditions of some ancillary services limit the ability to commit resources for other potential services.
  - DSR providers currently incur high transaction costs for bilateral contracts with limited coordination between different industry stakeholders.
- There is no alignment between renewable and EES policies. A significant increase in intermittent generation may cause increased stress on network capacity and operation. EES

[56] Initial Report on Industrial and Commercial DSR trials (CLNR L014, 2013); Different methods for the measure of the DSR deliver were trialled in winter 2012 and spring 2014 trials. The settlement process was a manual activity and it required an iterative process to agree final positions with the aggregator for winter 2012 trials;

is one of the options that can support mitigating these effects. There is however no specific incentive or requirement in Renewable Obligation Certificates (ROCs) or Feed in Tariffs (FiT) to mitigate the impact they can have on the network [23], nor are there specific requirements on intermittent embedded generation to provide system services[57].

3.2. Merchant EES operator barriers

- Limited transparency in generation, supply and network activities, limits the ability for merchant EES operators to develop business models.

3.3. DNO operator EES barriers

- Neither the Transmission System Operator nor the DNOs have a responsibility to locally balance demand and supply. This limits the opportunity for EES to support the uptake of distributed low carbon technologies by reducing local network impacts.

- Distribution licence holders are prohibited from holding generation licences, although a class exemption exists for smaller generators, allowing DNOs to own EES assets below 50MW (with individual exemptions possible for assets below 100MW). Typical EES assets are currently much lower in capacity. In practice this is therefore not a significant barrier to DNOs.

- The DNO faces restrictions on activities it can undertake that could distort competition in generation and supply. This limits the ability of DNOs to operate wholesale and balancing use cases of a storage asset. However, this can be mitigated by operationally separating the handling of electricity flows to a third party, or with other commercial models [25].

Similarly the limitation for DNOs that turnover from non-distribution activities must not exceed 2.5% of revenue does not likely limit the development of EES projects in the near future. This is not a material barrier, as consent can be sought from Ofgem to relax this limit [25].

[57] Under security of supply standards (ER P2/6), distributed generation is in effect considered a non-network solution that contributes to system security

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